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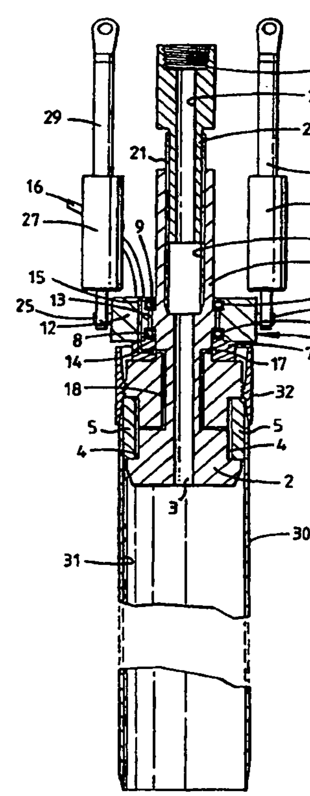
(57) Abstract

An apparatus for facilitating the connection of tubulars using a top drive, which apparatus comprises a body (2; 102) connectable to said top drive, said body (2; 102) comprising at least one gripping element (5; 105) radially displaceable by hydraulic or pneumatic fluid to drivingly engage said tubular (30; 110) to permit a screw connection between said tubular and a further tubular to be tightened to the required torque.



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CONNECTION OF TUBULARS USING A TOP DRIVE

This invention relates to an apparatus for facilitating the connection of tubulars using a top drive and is more particularly, but not exclusively, intended for facilitating the connection of a section or stand of casing to a string of casing.

In the construction of oil or gas wells it is usually necessary to line the borehole with a string of tubulars known as casing. Because of the length of the casing required, sections or stands of say two sections of casing are progressively added to the string as it is lowered into the well from a drilling platform. In particular, when it is desired to add a section or stand of casing the string is usually restrained from falling into the well by applying the slips of a spider located in the floor of the drilling platform. The new section or stand of casing is then moved from a rack to the well centre above the spider. The threaded pin of the section or stand of casing to be connected is then located over the threaded box of the casing in the well and the connection is made up by rotation therebetween. An elevator is then connected to the top of the new section or stand and the whole casing string lifted slightly to enable the slips of the spider to be released. The whole casing string is then lowered until the top of the section is adjacent the spider whereupon the slips of the spider are re-applied, the elevator disconnected and the process repeated.

It is common practice to use a power tong to torque the connection up to a predetermined torque in order to make the connection. The power tong is located on the platform, either on rails, or hung from a derrick on a chain. However, it has recently been proposed to use a top drive for making such connection. A “top drive” is a top driven rotational system substantially used for drilling purposes, assigned to the drawworks at a higher level than the elevator, as is previously known.

Because of the high costs associated with the construction of oil and gas wells time is critical and it has been observed by the applicants that the time to connect a tubular to a top drive using existing equipment could be reduced.

Accordingly there is provided an apparatus for facilitating the connection of tubulars using a top drive, which apparatus comprises a body connectable to said top drive, said body comprising at least one gripping element radially displaceable by hydraulic or pneumatic fluid to drivingly engage a tubular to permit a screw connection between said tubular and a further tubular to be tightened to the required torque.

Other features of the invention are set out in Claims 2 to 14.

The present invention also provides an apparatus for facilitating the connection of tubulars using a top drive, said apparatus comprising a body connectable to said top drive, said body comprising at least one gripping element radially displaceable to drivingly engage said tubular and a sealing packer to inhibit, in use, fluid in said tubular from escaping therefrom.

Preferably, said sealing packer can be actuated by hydraulic or pneumatic fluid.

One advantage of at least preferred embodiments of the invention is that the gripping elements transfer the full torque capacity of the top drive to the casing without damaging the pipe surface. Elastomeric jaws greatly reduce the marks made by the dies as compared to simple metal dies. Elastomeric jaws also enable pipes with differing inside diameters to be clamped with only one set of jaws.

The present invention also provides an apparatus for running tubulars into a borehole, said apparatus comprising a body provided with a wedge lock assembly and a hydraulically operable grapple to mechanically grip the inside wall of a tubular to be run into, or withdrawn from, the borehole, said grapple incorporating positive locking means to prevent inadvertent release of said grapple, said body further comprising means to prevent spillage of drilling fluid when the body is withdrawn from the tubular, a sealing packer for engagement with the tubular to permit fluid to be circulated within the tubular, and a stabbing guide.

Further features of the apparatus for running tubulars into a borehole in accordance with the present invention are set out in Claims 18 to 24.

In use, such an apparatus may be connected to a top-drive unit via a threaded connection, or to a kelly driven rig via a pump joint latched into an elevator. Both systems have available a means of connecting up to a circulating system that will permit the casing to be filled or circulated at any time during the running operation.

Casing is normally run by picking up a joint at a time, utilising single pickup elevators to bring the joint into the derrick and connect it to the previously run joint, whether it be by threaded connection or "mechanical latching or locking". The two joints are either screwed or locked together and then lowered into the well bore using elevators.

With heavy casing strings it is required that very large elevators are used to be able to handle the load. This often means that the top of the casing joint must be set 8–10 feet above the rig floor to permit disengagement to take place. Scaffolding is often required for the rig crews to be able to stab or connect the next joint to the string. It is also normal to either utilise a separate pack-off assembly, or a fillup hose that must be installed by the rig crew after it has been lowered and set in the slips.

Preferred embodiments of the present invention will permit the casing to be picked up by single pickup elevators, connected either by rotation or mechanical latch, and then the casing running tool to be "stabbed" into the bore of the top joint without damage, due to the rubber bull-nose guide. When the tool is at the correct depth of penetration within the casing bore, the hydraulic piston is actuated to drive the grapple down onto the wedge lock and secure the grapple to the casing wall. As the casing string is lifted, the wedge-lock continues to drive into the grapple bore, providing an ever increasing wedge lock. The compression spring installed within the hydraulic piston provides a "positive-lock" or failsafe should the hydraulic system fail for any reason.

When the apparatus is engaged, it is then possible to push, pull, or even rotate the casing string. A seal ring assembly is required to rotate the casing string, to permit constant control of the hydraulic actuating piston to be maintained.

Preferred embodiments of the apparatus are equipped with a through-bore to permit casing fillup and circulation to take place at any time. There may also be provided a pack-off that can be either inflatable or flow pressure operated.

The present invention also provides a top drive having an apparatus in accordance with the present invention attached thereto.

Some preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional side view of a first embodiment of an apparatus in accordance with the present invention inserted in a section of casing;

Figure 2 shows the apparatus of Figure 1 connected to a top drive and inserted in a section of casing;

Figure 3 shows a cross-sectional side view in perspective of part of a second embodiment of an apparatus in accordance with the present invention;

Figure 4 shows a cross-sectional side view of a third embodiment of an apparatus in accordance with the present invention; and

Figure 5 shows a cross-sectional side view of the embodiment of Figure 4 in use.

Referring to Figure 1 there is shown an apparatus which is generally identified by reference numeral 1.

The apparatus 1 comprises a cylindrical body 2 which has a central passage 3 therethrough. The cylindrical body 2 has circumferentially spaced recesses 4 thereabout in which respective gripping elements 5 are located.

The upper part 6 of the cylindrical body 2 is of a reduced outer diameter. The upper part 6 passes through a rotary transmission 7 and is rotatably supported by two bearings 8, 9 which are arranged in corresponding channels 10, 11 in an annular support 12. A circumferentially raised portion 13 between the two bearings 8, 9 is provided in the upper part 6 to inhibit longitudinal movement of the cylindrical body 2.

The rotary transmission 7 is mounted fast on the annular support 12 and is in sealing tight relation with the upper part 6 which is rotatable relative thereto. The rotary transmission 7 is provided with a feed passage 15 in the annular support 12 and with a feed line 16. The other end of the feed passage 14 is in fluid communication with a radial channel 17. Feed passages 18 are provided in the cylindrical body 2 to link the radial channel 17 with the circumferential recesses 4 behind each gripping element 5.

The upper part 6 is provided with internal splines 19 along the upper part of the passage 3. The lower end of a connecting member 20 is provided with corresponding external splines and is located in the upper part of the passage 3. The upper end of the connecting member 20 is provided with a circulating canal 22 and threads 23 for connection to a top drive (Figure 2).

The support member 12 is provided with two axles 24, 25 to which compensating cylinders 26, 27 are attached, the corresponding pistons 28, 29 being, in use, connected to the body of the top drive (Figure 2).

Gripping elements 5 are preferably based on the construction described in PCT Publication No. WO 94/05894 which is incorporated herein for all purposes, and sold by the applicants under the trade mark “MICRO-GRIP”.

The gripping elements 5 comprise a plurality of longitudinally extending strips (not shown) which are embedded side by side in an elastomeric base member (not shown). Each strip projects out from said elastomeric base member, and each strip has a pipe gripping edge (not shown) facing away from the elastomeric base member, so that channels are formed between adjacent strips to accommodate debris from the surface of the casing to be gripped. The pipe gripping edge may, for example, comprise teeth, so that the strips resemble saw blades, or may comprise particulate material bonded to the strips. This type of gripping element allows rotational torque to be applied to the tubular and longitudinal forces produced by circulating fluid within the tubular and the weight of the tubular to be taken.

The cylindrical body 2 is shown in Figure 1 in a section of casing 20 with gripping elements 5 in a radially extended position, engaging the inner wall 31 of the section of casing 30 beneath a threaded box 32.

In use, the pistons 28, 29 are connected to the stator 34 of the top drive 33 (Figure 2). The rotor 35 of the top drive 33 is connected to the connecting member 20. The section of casing 30 is positioned over the upper portion of a casing string using, for example, a pipe positioning device. The top drive 33 with the attached apparatus 1 is lowered so that the cylindrical body 2 thereof enters the casing 30. Alternatively, the section or stand of casing may be brought towards the apparatus 1 using the methods and apparatus disclosed in co-pending UK Patent Application No. 9818366.8 entitled "Methods and Apparatus for Facilitating the Connection of Tubulars Using a Top Drive" filed by the applicant for the present application on 24 August 1998. If the support member 12 hits the top of the threaded box 32, the compensating cylinders 26, 27, which contain compressed air, cushion the impact whilst the splines 19, 21 in the upper part 6 of the cylindrical body 2 will allow relative longitudinal movement between the apparatus 1 and the top drive 33 whilst being able to transmit rotation therebetween.

Hydraulic pressure is applied through feed line 16, feed passage 15, feed passage 14, radial channel 17, and feed passage 18 into recess 4 behind gripping elements 5,

forcing the gripping elements 5 radially outwardly to engage the inner wall 31 of the casing 30.

The top drive 33 may now be used to rotate the rotor 35 which in turn rotates the connecting member 20, the cylindrical body 2 and hence the casing 30. The compensating cylinders 26, 27 will allow a small downward movement as the threaded pin on the bottom of the casing enters the box on the top of the string, and may be controlled remotely. The compensating cylinders 26, 27 may be of the pneumatic compensating type, i.e. their internal pressure may be adjusted to compensate for the weight of the casing 30 so that movement of the tubular may be conducted with minimal force. Pneumatic compensating cylinders also reduce the risk of damage to the threads of the tubulars. This can conveniently be achieved by introducing pneumatic fluid into the cylinders 26, 27 and adjusting the pressure therein. Hydraulic cylinders may, however, be used or hydraulic cylinders provided with a pneumatic bellows system.

Once the joint is correctly tightened the elevator 37 is swung into position and the elevator slips therein (not shown) are actuated to grip the casing 30 beneath the box 32. The top drive 33 is then raised a small amount using the drawworks to enable the slips in the spider to be released and the top drive and casing string is then lowered.

As the casing is lowered liquid may be introduced into the casing 30 via the connecting canal 22 and the central passage 3. The introduction of such liquid is often desirable to facilitate the lowering of the casing.

Referring to Figure 3 there is shown an apparatus in accordance with a second embodiment of the present invention which is generally identified by the reference numeral 101.

The apparatus 101 is generally similar to that of Figure 1, in that it comprises a cylindrical body 102 which has a central passage 103 therethrough. The cylindrical

body 102 has recesses 104 thereabout in which gripping elements 105 are located. The gripping elements 105 are provided with recesses 106.

The cylindrical body 102 is also provided with a cylindrical sealing packer 107 arranged below the gripping elements 105. The cylindrical sealing packer 107 is provided with a recess 108. The cylindrical sealing packer 107 which is made from an elastomeric material is fast with the cylindrical body 102.

The cylindrical body 102 is provided with a feed passage 109 which is at the upper end connected to a hydraulic fluid supply, and at the other, to the recesses 106 and 108 in the gripping elements 105 and the cylindrical sealing packer 107 respectively.

In use, the apparatus 101 is connected to a top drive, such as that shown in Figure 2, and is inserted into the top of a section or stand of casing 110. Hydraulic fluid pressure is applied through feed passage 109 into recesses 106 and 108 which moves the gripping elements 105 into engagement with the inner wall 111 and the cylindrical sealing packer 107 into contact with the inner wall 111. The gripping elements 105 engage with the inner wall 111 of the casing 110 so that rotational force can be transmitted from the apparatus 101 to the casing 110. The sealing packer 107 substantially prevents any fluids such as mud from escaping between the apparatus 101 and the casing 110. This is particularly advantageous where it is desired to circulate fluid to facilitate running the casing. In particular, if the casing string becomes lodged on an obstruction, liquid can be pumped down the casing string under high pressure to remove the obstruction. The sealing packer 107 facilitates this operation by inhibiting liquid under high pressure escaping through the top of the casing 30.

Referring to Figures 4 and 5 there is shown an apparatus in accordance with a third embodiment of the present invention which is generally identified by the reference numeral 201.

The apparatus comprises a cylindrical body 202 with a threaded connection 203 at the upper end for connection to a top drive. Attached to the cylindrical body 202, or machined into it, is a hydraulic cylinder 204, with threaded ports 205, 206 at opposite ends. These ports 205 and 206 permit hydraulic fluid to be injected under pressure to manipulate a hydraulic piston 207, secured within the cylinder by a threaded lock ring 208. A compression spring 209 is located in the cylinder 204 above the piston 207.

A grapple 210, provided with serrated teeth machined into its outer surface, is provided around the cylindrical body 202 below the hydraulic cylinder 204. The grapple 210 is connected to the hydraulic piston 207 by a threaded connection 211. A corresponding wedge lock 212 is provided on the cylindrical body 202. The grapple 210 and corresponding wedge lock 212 are located, in use, inside a casing 213. The piston 207 and lock ring 208 are fitted with seal rings (not shown) to prevent hydraulic fluid leakage.

A mud-check valve 214 is thread connected at the lower end of the wedge lock 212. Below this valve is a rubber pack-off assembly 215. These prevent spillage of drilling fluid when the apparatus 201 is removed from within the casing joint 213. The pack-off 215 can be energised by either internal mud pressure or external mud flow.

In use, the apparatus 201 is lowered into the casing joint 213 as shown in Figure 4. The grapple 210 is held out of contact with the wedge lock 212 by hydraulic fluid injected into port 206.

When the apparatus 201 is located at the correct installation depth within the casing 213, the pressure and fluid is released from port 206, and fluid is injected into port 205. This pushes the piston 207 downwards, pressing the grapple 210 against the wedge lock 212. The grapple 210 is forced outwards by the wedge lock 212, forming a mechanical friction grip against the inner wall of the casing 213. This is shown in Figure 5.

The rig lifting equipment (not shown) raises the apparatus 201, and this causes the wedge lock 212 to be pulled upwards against the inner surface of the grapple 210, ensuring that constant outward pressure is applied to the grapple 210. The grip becomes tighter with increasing pull exerted by the rig lifting equipment.

Should hydraulic pressure be lost from port 205, the compression spring 209 ensures that the piston 207 continues to press the grapple 210 against the wedge lock 212, preventing release of the grapple from the wedge lock.

The apparatus 201 and casing 213 are then lowered into the well bore and the casing is secured. The apparatus 201 is lowered so that it supports its own weight only, and hydraulic fluid is then pumped out of port 205 and into port 206 to release the grapple 210 from the wedge lock 212 and thus release the apparatus 201 from the casing 213. The apparatus is then removed from the casing joint 213 and the process is repeated.

It is envisaged that the apparatus as described above could be used in conjunction with any of the apparatus and used with any of the methods as described in the co-pending International Applications based on GB Application Nos. 9818360.1, 9818363.5 and 9818366.8 entitled “An Apparatus for Facilitating the Connection of Tubulars Using a Top Drive”, “Method and Apparatus for Facilitating the Connection of Tubulars using a Top Drive” and “Method and Apparatus for Facilitating the Connection of Tubulars using a Top Drive” respectively.

CLAIMS:

1. An apparatus for facilitating the connection of tubulars using a top drive, which apparatus comprises a body (2; 102) connectable to said top drive, said body (2; 102) comprising at least one gripping element (5; 105) radially displaceable by hydraulic or pneumatic fluid to drivingly engage a tubular (30; 110) to permit a screw connection between said tubular and a further tubular to be tightened to the required torque.

2. An apparatus as claimed in claim 1, wherein said at least one gripping element (5; 105) has an elastomeric gripping surface incorporating projecting metal inserts or saw blades capable of transmitting said torque.

3. An apparatus as claimed in claim 1 or 2, wherein said at least one gripping element (5; 105) is movable radially outwardly from said body (2; 102) to engage the inside wall (31; 111) of said tubular (30; 110)

4. An apparatus as claimed in claim 1, 2 or 3, wherein said body (2; 102) is connectable to a rotor (35) of said top drive in order to rotate said apparatus.

5. An apparatus as claimed in claim 1, 2, 3 or 4, further comprising a sealing packer (107) for engagement with said tubular.

6. An apparatus as claimed in claim 5, wherein said sealing packer (107) can be activated by hydraulic or pneumatic fluid.

7. An apparatus as claimed in any preceding claim, wherein said body (2; 102) is provided with a passage (3; 103) therethrough to allow excess fluid in said tubular to escape therefrom.

8. An apparatus as claimed in any preceding claim, further comprising a support (12) for supporting the weight of said tubular during driving engagement of the tubular by said at least one gripping element (5; 105).

9. An apparatus as claimed in claim 8, wherein said support (12) is connectable to a stator of said top drive.

10. An apparatus as claimed in claim 8 or 9, wherein said support (12) is carried by compensating pistons (26, 27) connectable to said top drive.

11. An apparatus as claimed in claim 10, wherein said compensating pistons (26, 27) are pneumatically operable and are adjustable to compensate for different weights of tubular.

12. An apparatus as claimed in any preceding claim, wherein an upper part of said body (2) comprises a splined recess into which a splined rotor or splined connecting member (20) may be located.

13. An apparatus as claimed in claim 8, 9, 10 or 11, wherein said support (12) is arranged circumjacent an upper part of said body (2) with a bearing (8, 9) arranged therebetween to allow said body (2) to rotate with respect to said support (12).

14. An apparatus as claimed in any preceding claim, further comprising a rotary transmission (7) to allow hydraulic or pneumatic fluid to pass through said body (2; 102).

15. An apparatus for facilitating the connection of tubulars using a top drive, said apparatus comprising a body (102) connectable to said top drive, said body (102) comprising at least one gripping element (105) radially displaceable to drivingly engage a tubular (110) and a sealing packer (107) to inhibit, in use, fluid in said tubular from escaping therefrom.

16. An apparatus as claimed in claim 15, wherein said sealing packer can be actuated by hydraulic or pneumatic fluid.

17. An apparatus (201) for running tubulars (213) into a borehole, said apparatus comprising a body (202) provided with a wedge lock assembly (212) and a hydraulically operable grapple (210) to mechanically grip the inside wall of a tubular (213) to be run into, or withdrawn from, the borehole, said grapple incorporating positive locking means to prevent inadvertent release of said grapple, said body further comprising means (214) to prevent spillage of drilling fluid when the body is withdrawn from the tubular, a sealing packer (215) for engagement with the tubular to permit fluid to be circulated within the tubular, and a stabbing guide (216).

18. An apparatus as claimed in claim 17, wherein the grapple (210) is connected to a hydraulic piston assembly (204,207) to permit engagement of the grapple with the inside walls of the tubular (213) to enable mechanical lift to be applied to the tubular.

19. An apparatus as claimed in claim 18, wherein the hydraulic piston assembly (204,207) is biased towards a failsafe position by a compression spring (209).

20. An apparatus as claimed in claim 18 or 19, wherein the hydraulic piston assembly incorporates a cylinder (204) which is either formed integrally with the body (202) or is attached thereto by threading or flanging.

21. An apparatus as claimed in claim 18, 19 or 20, wherein the body (202) is provided with a slip-ring assembly to enable hydraulic fluid to be supplied to the hydraulic piston assembly (204,207) whilst at the same time permitting rotation of the body and the tubular (213) thereon.

22. An apparatus as claimed in any one of claims 17 to 21, which is adapted to be used with different sizes of tubular.

23. An apparatus as claimed in any one of claims 17 to 22, wherein the body (202) is fitted with a bull-nose guide (216) to prevent damage to the top of the tubular when the body is introduced into the tubular.

24. An apparatus as claimed in any one of claims 17 to 23, wherein the body (202) is provided with a through bore (217) to permit circulation of fluid.

25. A top drive having an apparatus as claimed in any preceding claim attached thereto.

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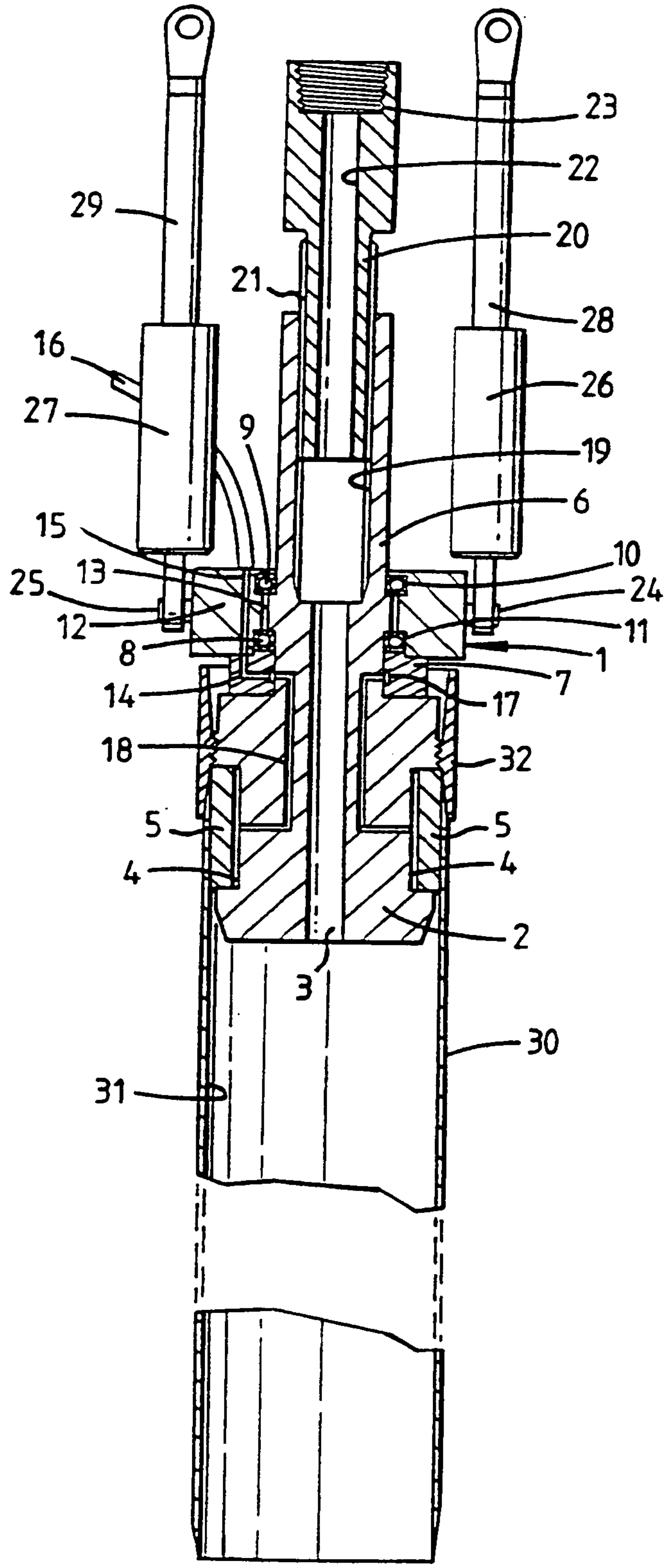
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Fig. 1

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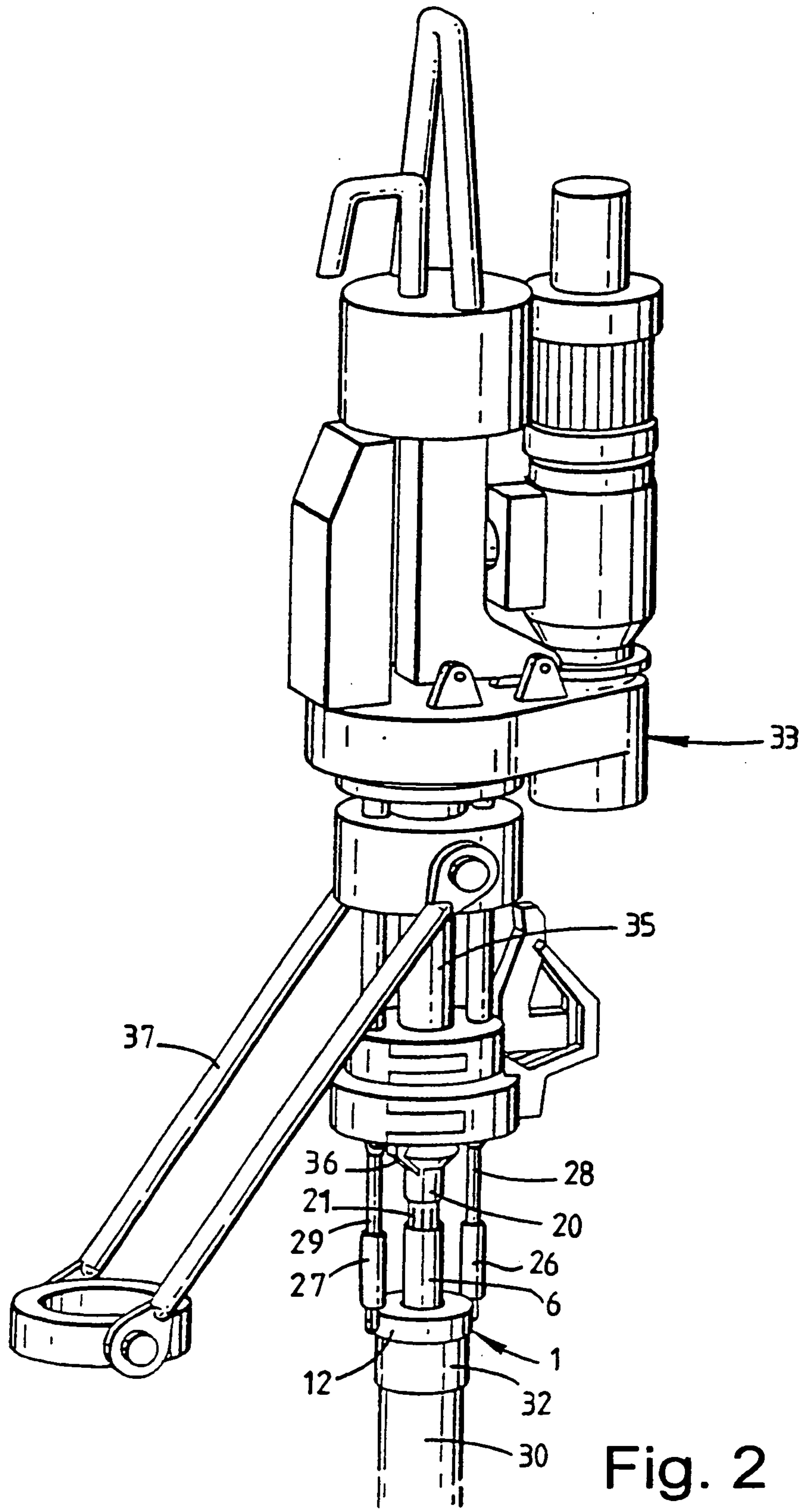

Fig. 2

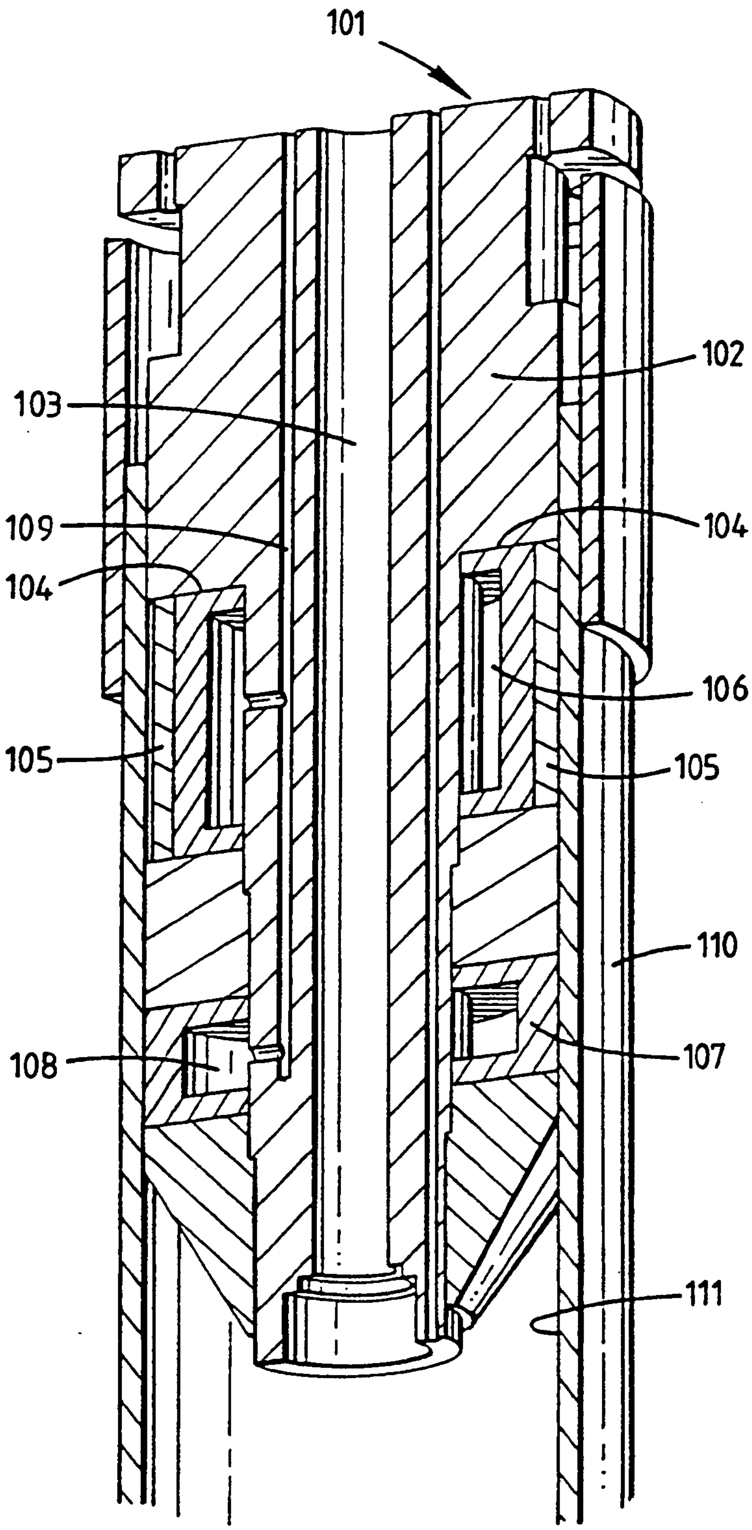

Fig. 3

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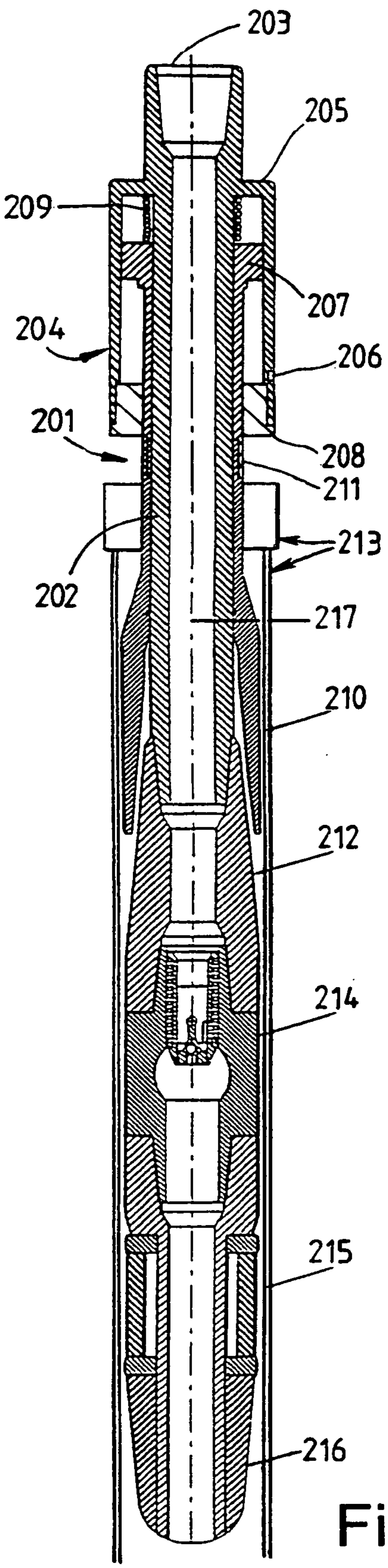
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Fig. 4

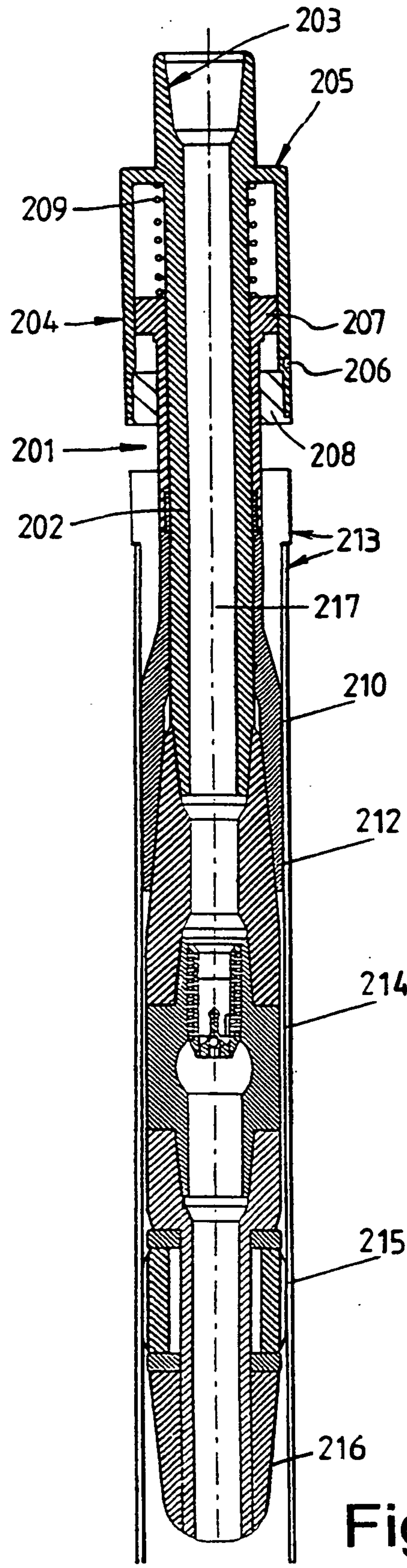
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Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/02203

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B19/16 E21B19/06 E21B31/03 E21B33/126 E21B43/10
E21B23/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 297 833 A (WILLIS CLYDE A ET AL) 29 March 1994 (1994-03-29)	1,4,7-11
A	the whole document	2,3,14
A	WO 98 11322 A (GJEDEBO JON ;HITEC ASA (NO)) 19 March 1998 (1998-03-19) figures	1-3,15, 16
A	EP 0 525 247 A (APACHE CORP) 3 February 1993 (1993-02-03) figures 3,3A	1
A	WO 98 05844 A (LUCAS BRIAN RONALD ;STOKKA ARNOLD (NO); WEATHERFORD LAMB (US)) 12 February 1998 (1998-02-12) abstract; figure 1	12,13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Fonseca Fernandez, H

3

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intr ional Application No
PCT/GB 99/02203

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 762 187 A (HANEY KEITH M) 9 August 1988 (1988-08-09) abstract; figures	2,3
A	US 5 009 265 A (BAILEY THOMAS F ET AL) 23 April 1991 (1991-04-23) abstract	5,6
A	GB 2 275 486 A (WEPCO AS) 31 August 1994 (1994-08-31) abstract; figures	1
A	US 5 255 751 A (STOGNER HUEY) 26 October 1993 (1993-10-26)	
X	WO 96 18799 A (WEATHERFORD LAMB ;LUCAS BRIAN RONALD (GB); STOKKA ARNOLD (NO)) 20 June 1996 (1996-06-20) page 7 -page 9; figure 3	15,16
Y	WO 93 07358 A (WEPCO AS) 15 April 1993 (1993-04-15) claim 1; figures	15,16
Y	US 5 735 348 A (HAWKINS III SAMUEL P) 7 April 1998 (1998-04-07)	15,16
A	column 5; figure 1	5,6
A	US 4 605 077 A (BOYADJIEFF GEORGE I) 12 August 1986 (1986-08-12)	
A	US 4 287 949 A (LINDSEY JR HIRAM E) 8 September 1981 (1981-09-08) claim 1	17-20, 22,24,25
A	US 4 580 631 A (BAUGH HOLLIS A) 8 April 1986 (1986-04-08) abstract	17,21, 22,24,25
A	GB 2 310 678 A (SMITH INTERNATIONAL) 3 September 1997 (1997-09-03) claim 1	17,18, 20,24,25
A	US 5 553 672 A (SMITH JR SIDNEY K ET AL) 10 September 1996 (1996-09-10) abstract	17

3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 99/02203

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-14

   Apparatus for connecting and desconnecting sections of casing or string using a gripping element supported by a top drive

2. Claims: 15-16

   Apparatus for connecting and desconnecting sections of casing or string using a gripping element supported by a top drive and having means to inhibit, in use, fluid in the string from escaping therefrom.

3. Claims: 17-25

   Apparatus for running tubulars into a borehole using a hydraulically operated grapple element,having a positive locking means to prevent inadvertent release of said grapple and means to prevent spillage of fluid when the apparatus is withdrawn from the tubular.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/02203

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 5297833	A	29-03-1994	AU	5605194	A	08-06-1994
			CA	2148346	A,C	26-05-1994
			EP	0701531	A	20-03-1996
			WO	9411291	A	26-05-1994
WO 9811322	A	19-03-1998	NO	963823	A	16-03-1998
			AU	4323597	A	02-04-1998
			GB	2332009	A	09-06-1999
EP 0525247	A	03-02-1993	US	5036927	A	06-08-1991
WO 9805844	A	12-02-1998	GB	2315696	A	11-02-1998
			AU	3766297	A	25-02-1998
			EP	0917615	A	26-05-1999
			NO	990392	A	19-03-1999
			US	5839330	A	24-11-1998
US 4762187	A	09-08-1988	AT	90141	T	15-06-1993
			AU	1400188	A	06-10-1988
			CA	1299166	A	21-04-1992
			DE	3881429	A	08-07-1993
			EP	0285386	A	05-10-1988
			NO	881445	A	03-10-1988
US 5009265	A	23-04-1991	AU	617586	B	28-11-1991
			AU	4928090	A	13-09-1990
			AU	634093	B	11-02-1993
			AU	8389391	A	14-11-1991
			CA	2010326	A,C	21-08-1990
			IT	1240767	B	17-12-1993
			JP	2292492	A	03-12-1990
			NZ	232571	A	25-02-1993
GB 2275486	A	31-08-1994	NO	173750	C	26-01-1994
			AU	2754092	A	03-05-1993
			WO	9307358	A	15-04-1993
US 5255751	A	26-10-1993	AU	2923192	A	07-06-1993
			AU	3067492	A	07-06-1993
			CA	2122622	A	13-05-1993
			CA	2122623	A	13-05-1993
			EP	0706605	A	17-04-1996
			EP	0881352	A	02-12-1998
			WO	9309330	A	13-05-1993
			WO	9309331	A	13-05-1993
			US	5351767	A	04-10-1994
WO 9618799	A	20-06-1996	AU	4266796	A	03-07-1996
WO 9307358	A	15-04-1993	NO	173750	C	26-01-1994
			AU	2754092	A	03-05-1993
			GB	2275486	A,B	31-08-1994
US 5735348	A	07-04-1998	EP	0929731	A	21-07-1999
			NO	991615	A	03-06-1999
			WO	9814688	A	09-04-1998
			US	5918673	A	06-07-1999

Form PCT/ISA/210 (patent family annex) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/02203

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 4605077	A	12-08-1986	CA	1246048	A	06-12-1988
			EP	0185605	A	25-06-1986
			JP	1590532	C	30-11-1990
			JP	2014518	B	09-04-1990
			JP	61191790	A	26-08-1986
			NO	854826	A	05-06-1986
US 4287949	A	08-09-1981	US	RE31881	E	14-05-1985
US 4580631	A	08-04-1986	NONE			
GB 2310678	A	03-09-1997	US	5887660	A	30-03-1999
			GB	2310679	A	03-09-1999
			US	5884702	A	23-03-1999
US 5553672	A	10-09-1996	CA	2160048	A	08-04-1996
			GB	2293842	A,B	10-04-1996
			GB	2320939	A,B	08-07-1998
			NO	953978	A	09-04-1996

COPY

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference (if desired) (12 characters maximum): WEAA, 281-PCT

Box No. I TITLE OF INVENTION "An Apparatus for facilitating the connection of Tubulars using a Top Drive"

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Weatherford/Lamb, Inc,
c/o CSC - The United States Corporation Company
1013 Centre Road
Wilmington
Delaware 19805
USA

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(that is, country)* of nationality: USA

State *(that is, country)* of residence: USA

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

PIETRAS, Bernd-Georg
Sandriedeweg 12
D-30900 Wedemark
Germany

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: Germany

State *(that is, country)* of residence: Germany

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

HARDING, Richard Patrick
Marks & Clerk
4220 Nash Court
Oxford Business Park South
Oxford, OX4 2RU
United Kingdom

Telephone No. +44 1865 397900

Facsimile No. +44 1865 397919

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Sheet No. ..2....

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

APPLETON, Robert Patrick
Glenburn House
Tornaveen
Banchory
Aberdeenshire, AB31 4NV
Scotland
United Kingdom

This person is:

☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: United Kingdom

State *(that is, country)* of residence: United Kingdom

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

☐ applicant only
☐ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

☐ applicant only
☐ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

☐ applicant only
☐ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Sheet No. ...3..

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes: at least one must be marked)*:

Regional Patent

☐ **AP** **ARIPO Patent: GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☐ **EA** **Eurasian Patent: AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent: AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☐ **OA** **OAPI Patent: BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* ....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

☐ **AE** United Arab Emirates
☐ **AL** Albania ....
☐ **AM** Armenia ....
☐ **AT** Austria ....
☒ **AU** Australia ....
☐ **AZ** Azerbaijan
☐ **BA** Bosnia and Herzegovina ....
☐ **BB** Barbados
☐ **BG** Bulgaria ....
☐ **BR** Brazil ....
☐ **BY** Belarus ....
☒ **CA** Canada
☐ **CH and LI** Switzerland and Liechtenstein
☐ **CN** China ....
☐ **CU** Cuba ....
☐ **CZ** Czech Republic ....
☐ **DE** Germany ....
☐ **DK** Denmark ....
☐ **EE** Estonia ....
☐ **ES** Spain ....
☐ **FI** Finland ....
☐ **GB** United Kingdom
☐ **GD** Grenada
☐ **GE** Georgia ....
☐ **GH** Ghana ....
☐ **GM** Gambia
☐ **HR** Croatia ....
☐ **HU** Hungary ....
☐ **ID** Indonesia
☐ **IL** Israel ....
☐ **IN** India ....
☐ **IS** Iceland
☐ **JP** Japan ....
☐ **KE** Kenya ....
☐ **KG** Kyrgyzstan ....
☐ **KP** Democratic People's Republic of Korea ....
☐ **KR** Republic of Korea ....
☐ **KZ** Kazakhstan ....
☐ **LC** Saint Lucia
☐ **LK** Sri Lanka
☐ **LR** Liberia
☐ **LS** Lesotho ....
☐ **LT** Lithuania
☐ **LU** Luxembourg
☐ **LV** Latvia
☐ **MD** Republic of Moldova ....
☐ **MG** Madagascar ....
☐ **MK** The former Yugoslav Republic of Macedonia ....
☐ **MN** Mongolia
☐ **MW** Malawi ....
☐ **MX** Mexico ....
☒ **NO** Norway
☐ **NZ** New Zealand ....
☐ **PL** Poland ....
☐ **PT** Portugal ....
☐ **RO** Romania
☐ **RU** Russian Federation ....
☐ **SD** Sudan
☐ **SE** Sweden
☐ **SG** Singapore
☐ **SI** Slovenia ....
☐ **SK** Slovakia ....
☐ **SL** Sierra Leone ....
☐ **TJ** Tajikistan ....
☐ **TM** Turkmenistan ....
☐ **TR** Turkey ....
☐ **TT** Trinidad and Tobago ....
☐ **UA** Ukraine ....
☐ **UG** Uganda ....
☒ **US** United States of America ....
☐ **UZ** Uzbekistan ....
☐ **VN** Viet Nam ....
☐ **YU** Yugoslavia ....
☐ **ZA** South Africa ....
☐ **ZW** Zimbabwe ....

Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet:

☐ ....
☐ ....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Sheet No. ...4...

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 22 July 1998 22/7/98	9815809.0	GB		
item (2) 24 August 1998 24/8/98	9818358.5	GB		
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): 1 and 2

* *Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*:

ISA / EP

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*:

Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following number of sheets:

request	: 4
description (excluding sequence listing part)	: 10
claims	: 4
abstract	: 1
drawings	: 4
sequence listing part of description	:
Total number of sheets	: 23

This international application is accompanied by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☒ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☒ other *(specify)*: FORM 23/77

Figure of the drawings which should accompany the abstract: 1

Language of filing of the international application: ENGLISH

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

HARDING, Richard Patrick
Agent

For receiving Office use only

1. Date of actual receipt of the purported international application:
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA /
6. ☐ Transmittal of search copy delayed until search fee is paid.

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

This sheet is not part of and does not count as a sheet of the international application.

PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International application No.

Date stamp of the receiving Office

Applicant's or agent's file reference: RPH.P50717PC

Applicant

Weatherford/Lamb, Inc. et. al.

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE . . . . 55.00 T
2. SEARCH FEE . . . . 812.00 S

   International search to be carried out by EPO

   (If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

   Basic Fee

   The international application contains ______ sheets.

   first 30 sheets 285.00 b1

   ______ remaining sheets x ______ additional amount = ______ b2

   Add amounts entered at b1 and b2 and enter total at B . . . . 285.00 B

   Designation Fees

   The international application contains ______ designations.

   5 number of designation fees payable *(maximum 10)* x 65 amount of designation fee = 325.00 D

   Add amounts entered at B and D and enter total at I . . . . 610.00 I

   (Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT *(if applicable)* . . . . 44.00 P
5. TOTAL FEES PAYABLE 1,521.00

   Add amounts entered at T, S, I and P, and enter total in the TOTAL box — TOTAL

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

☐ authorization to charge deposit account (see below)	☐ bank draft	☐ coupons
☒ cheque	☐ cash	☐ other *(specify)*:
☐ postal money order	☐ revenue stamps	

DEPOSIT ACCOUNT AUTHORIZATION *(this mode of payment may not be available at all receiving Offices)*

The RO/ ______

☐ is hereby authorized to charge the total fees indicated above to my deposit account.

☒ *(this check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit)* is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.

☐ is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit account.

D01063 — Deposit Account No.

22/7/99 — Date *(day/month/year)*

Marks & Clerk — Signature

09/509074

09/509073

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference WEAA, 281-PCT	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 99/02203	International filing date *(day/month/year)* 22/07/1999	(Earliest) Priority Date *(day/month/year)* 22/07/1998
Applicant WEATHERFORD/LAMB, INC. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 5 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
      - [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :
      - [ ] contained in the international application in written form.
      - [ ] filed together with the international application in computer readable form.
      - [ ] furnished subsequently to this Authority in written form.
      - [ ] furnished subsequently to this Authority in computer readble form.
      - [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
      - [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished
2. [ ] **Certain claims were found unsearchable** (See Box I).
3. [X] **Unity of invention is lacking** (see Box II).
4. With regard to the **title**,
   - [ ] the text is approved as submitted by the applicant.
   - [X] the text has been established by this Authority to read as follows:

   CONNECTION OF TUBULARS USING A TOP DRIVE

5. With regard to the **abstract**,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. The figure of the **drawings** to be published with the abstract is Figure No. 1
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 99/02203

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-14

   Apparatus for connecting and desconnecting sections of casing or string using a gripping element supported by a top drive

2. Claims: 15-16

   Apparatus for connecting and desconnecting sections of casing or string using a gripping element supported by a top drive and having means to inhibit, in use, fluid in the string from escaping therefrom.

3. Claims: 17-25

   Apparatus for running tubulars into a borehole using a hydraulically operated grapple element,having a positive locking means to prevent inadvertent release of said grapple and means to prevent spillage of fluid when the apparatus is withdrawn from the tubular.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/02203

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B19/16 E21B19/06 E21B31/03 E21B33/126 E21B43/10
E21B23/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 5 297 833 A (WILLIS CLYDE A ET AL) 29 March 1994 (1994-03-29) the whole document	1,4,7-11 2,3,14
A	WO 98 11322 A (GJEDEBO JON ;HITEC ASA (NO)) 19 March 1998 (1998-03-19) figures	1-3,15, 16
A	EP 0 525 247 A (APACHE CORP) 3 February 1993 (1993-02-03) figures 3,3A	1
A	WO 98 05844 A (LUCAS BRIAN RONALD ;STOKKA ARNOLD (NO); WEATHERFORD LAMB (US)) 12 February 1998 (1998-02-12) abstract; figure 1	12,13

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 November 1999	30. 11. 1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Fonseca Fernandez, H

3

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 762 187 A (HANEY KEITH M) 9 August 1988 (1988-08-09) abstract; figures	2,3
A	US 5 009 265 A (BAILEY THOMAS F ET AL) 23 April 1991 (1991-04-23) abstract	5,6
A	GB 2 275 486 A (WEPCO AS) 31 August 1994 (1994-08-31) abstract; figures	1
A	US 5 255 751 A (STOGNER HUEY) 26 October 1993 (1993-10-26)	
X	WO 96 18799 A (WEATHERFORD LAMB ;LUCAS BRIAN RONALD (GB); STOKKA ARNOLD (NO)) 20 June 1996 (1996-06-20) page 7 -page 9; figure 3	15,16
Y	WO 93 07358 A (WEPCO AS) 15 April 1993 (1993-04-15) claim 1; figures	15,16
Y	US 5 735 348 A (HAWKINS III SAMUEL P) 7 April 1998 (1998-04-07)	15,16
A	column 5; figure 1	5,6
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/02203

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(43) Date of A Publication 03.09.1997

(21) Application No 9704184.2

(22) Date of Filing 28.02.1997

(30) Priority Data
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08782416 14.01.1997

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(51) INT CL^6
E21B 33/14 43/10

(52) UK CL (Edition O)
E1F FJT FKG

(56) Documents Cited
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(58) Field of Search
UK CL (Edition O) E1F FJT FJU FKA FKG
INT CL^6 E21B 33/12 33/13 33/14 33/16 43/10
Online: WPI

(54) A packer for a wellbore

(57) A liner packer assembly includes a liner packer (40) having a tubular body with an aperture (80) for the flow of wellbore fluids. A packing element (90) is movably disposed on the tubular body between an open position on one side of the aperture (80) for allowing wellbore fluids to flow through the aperture (80) to a closed position on the other side of the aperture for closing flow through the aperture and for packing off the annulus between the packer (40) and an outer casing (14). During the cementing operation, drilling fluids and cement are allowed to flow through the annular area formed by the packer (40) and outer casing (14) and also through the aperture (80) in the tubular body of the packer (40) and up the inner annular area formed by the packer (40) and inner tubular string (as shown by the arrow). The inner and outer annular areas around the packer (40) together approximate the flow area below the packer (40) between the inner tubular string and the outer casing (14) in order to prevent a restriction of fluid flow around the packer.

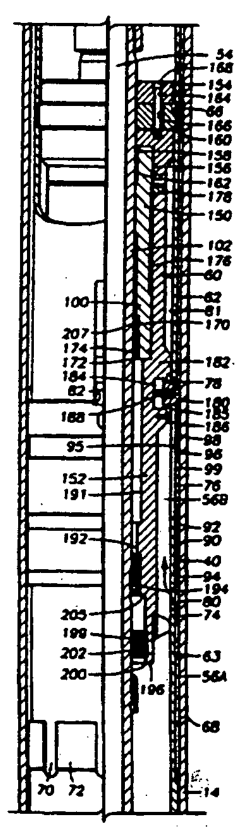

FIG. 5

GB 2 310 678 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

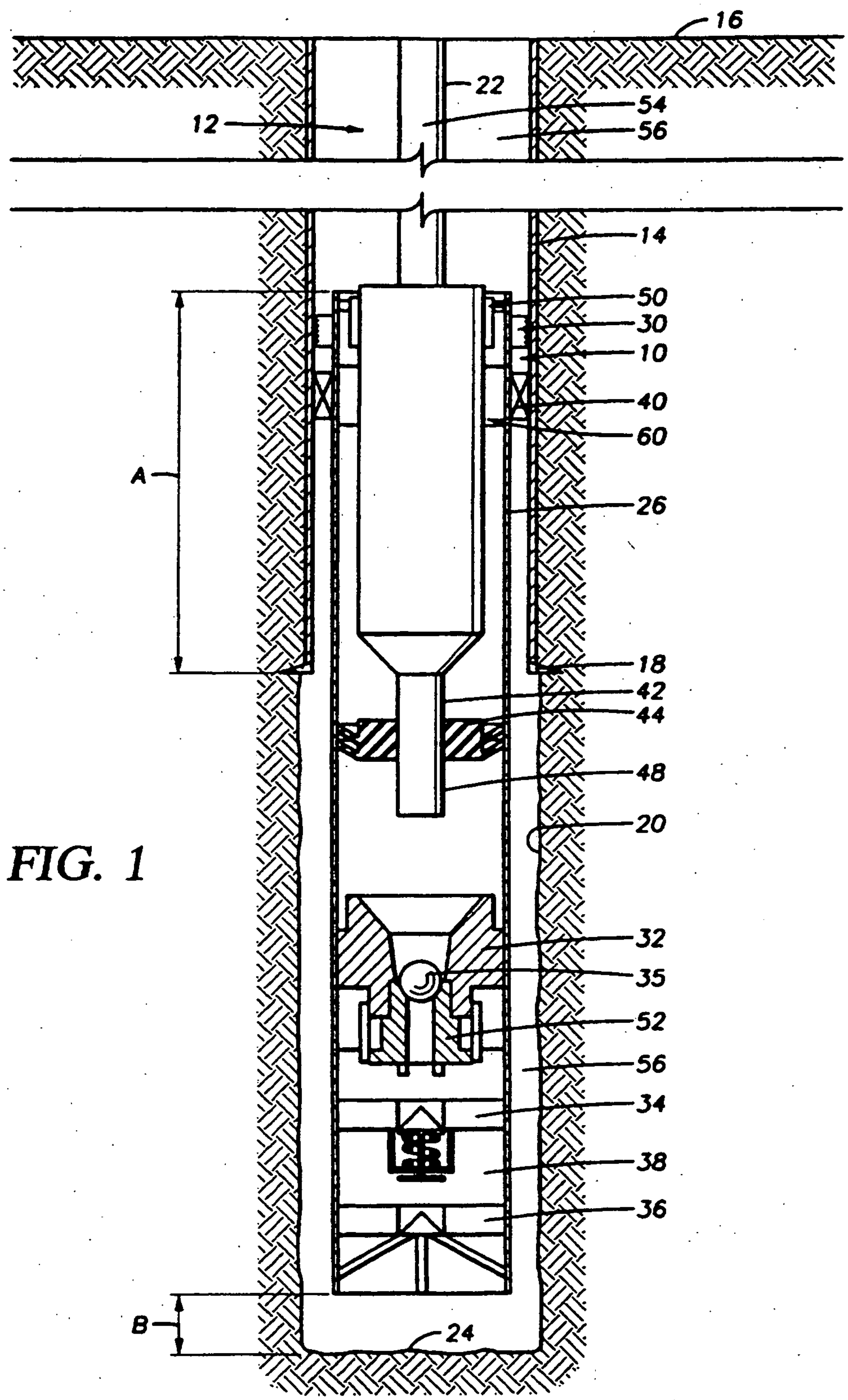
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FIG. 1

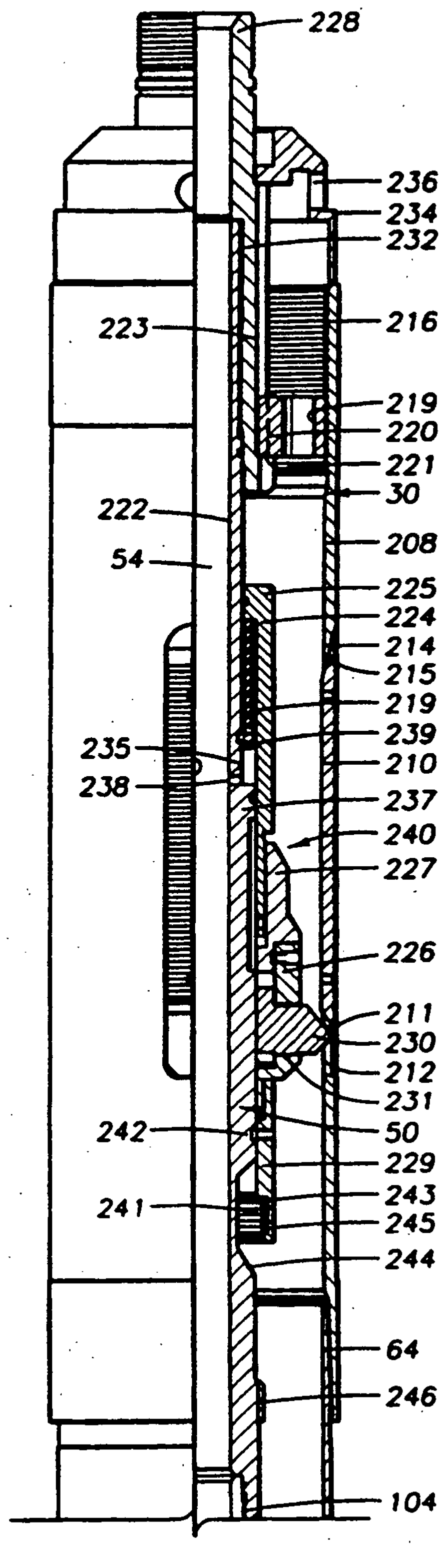
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FIG. 2A

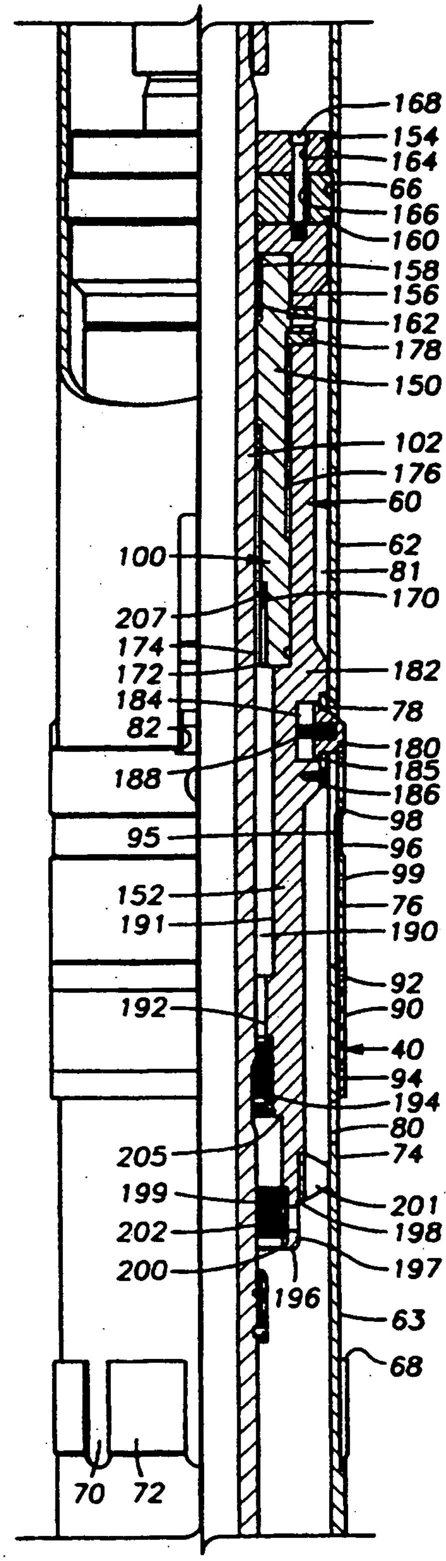
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FIG. 2B

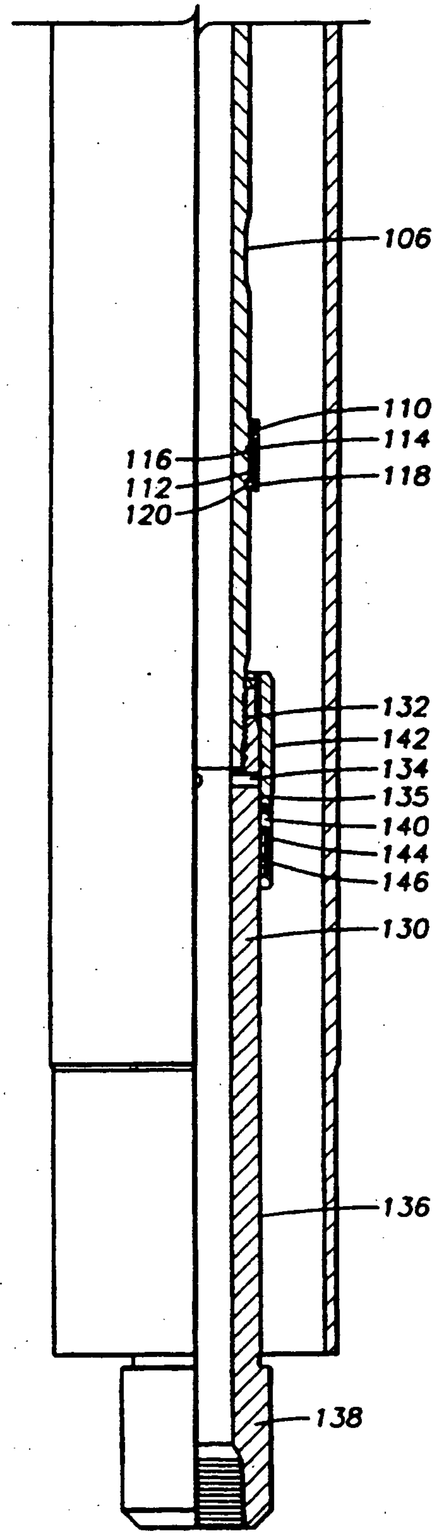
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FIG. 2C

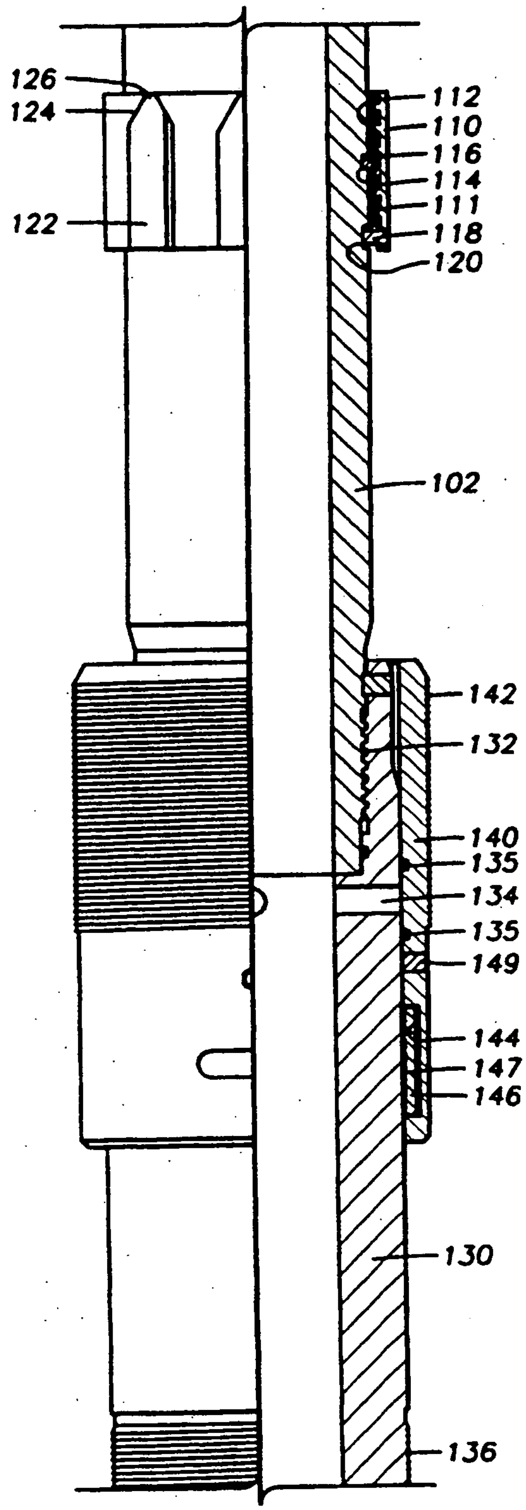
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FIG. 3

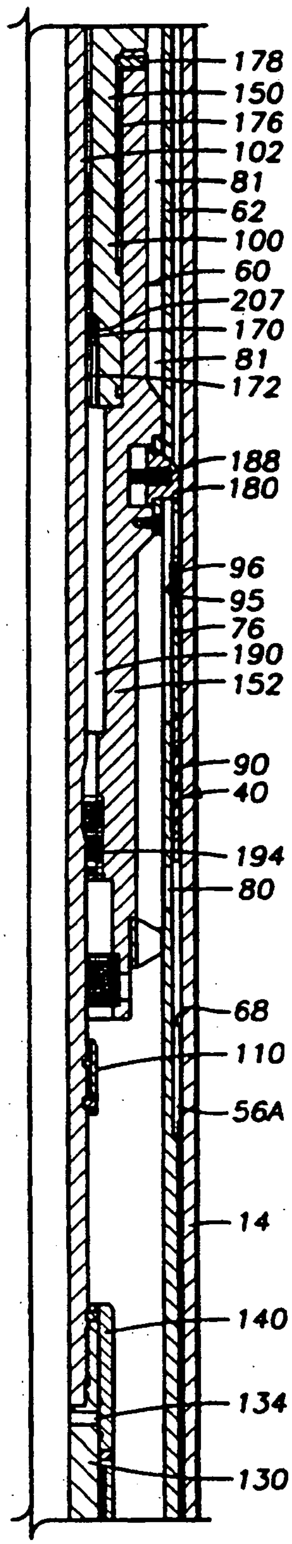

FIG. 4A

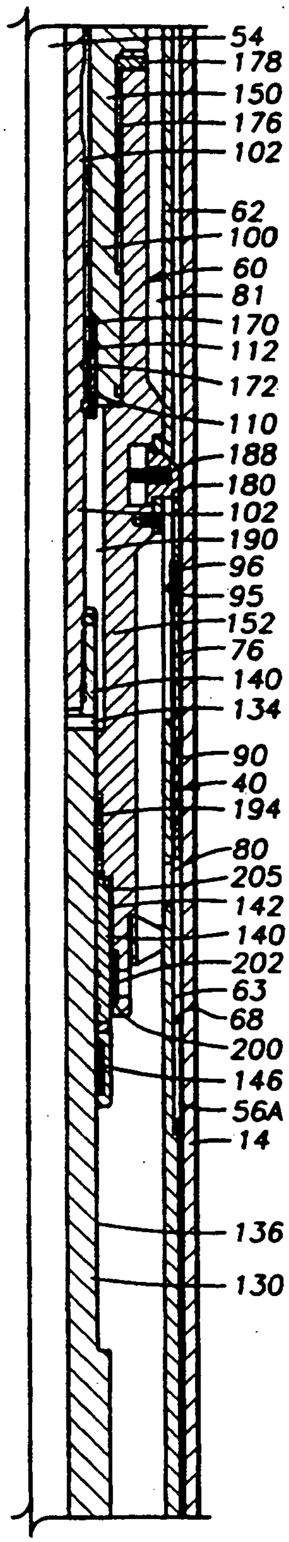

FIG. 4B

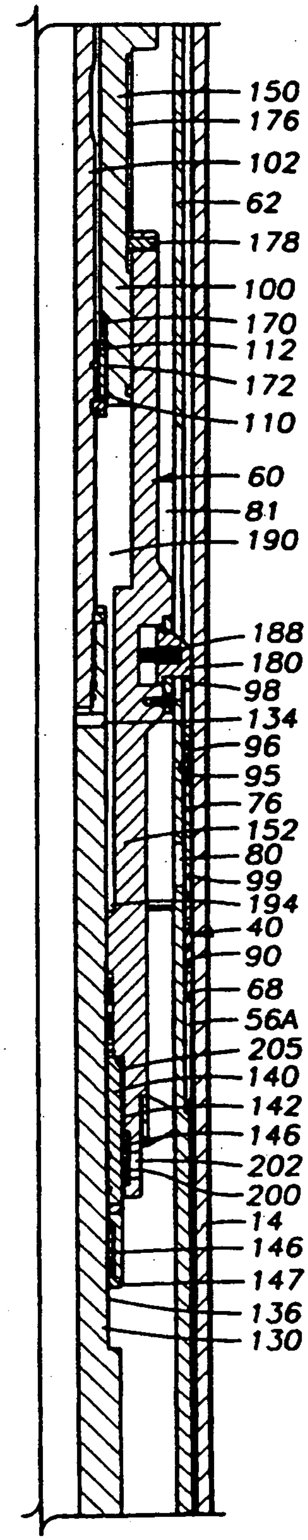

FIG. 4C

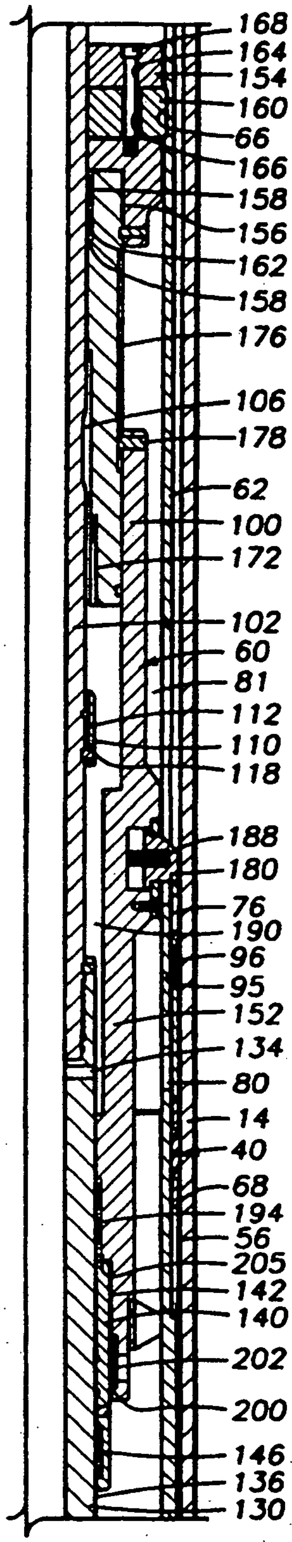

FIG. 4D

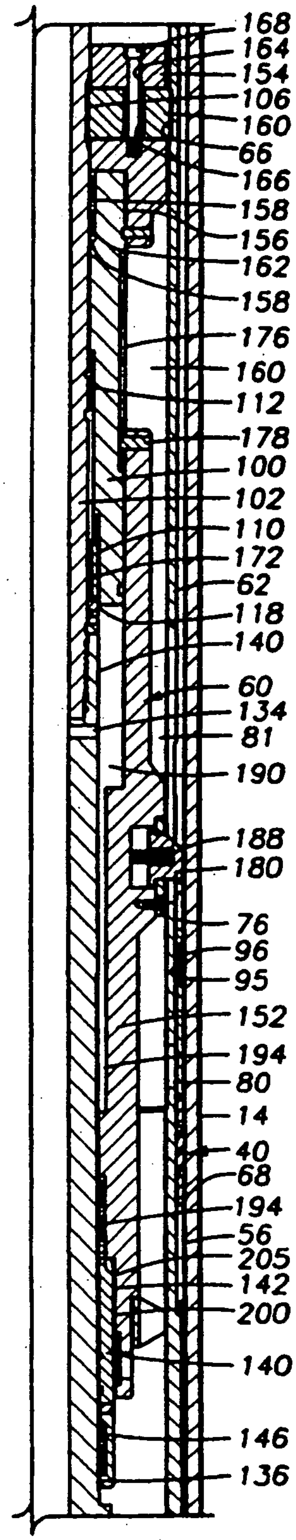

FIG. 4E

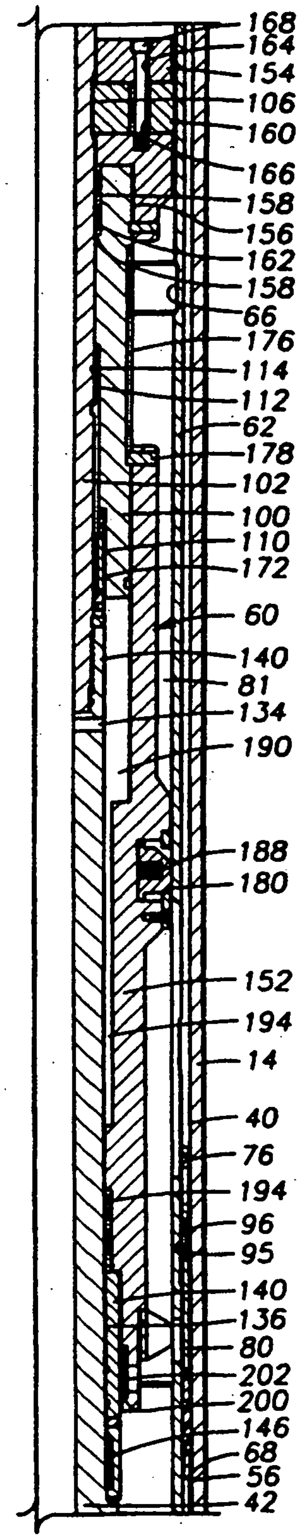

FIG. 4F

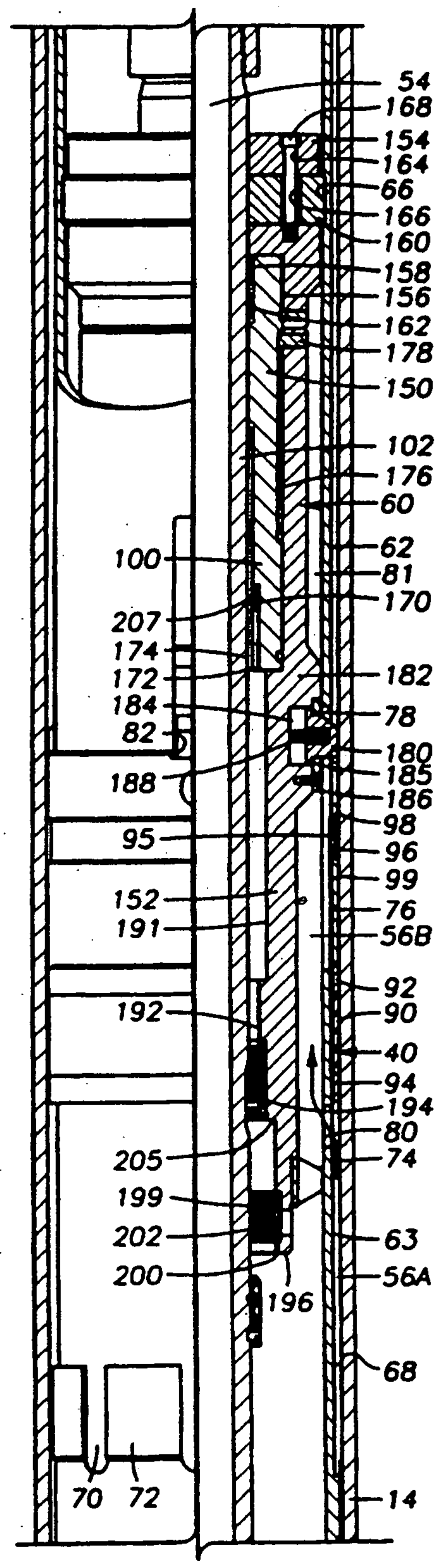
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FIG. 5

2310678

PACKER FOR A WELLBORE

The present invention relates to a packer and to a method of cementing a well.

In embodiments, the present invention relates a packer for sealing with an outer casing to prevent the flow of wellbore fluids and to a method and apparatus for cementing and packing off a liner within a well, and more particularly to a one trip liner packer, and still more particularly to a liner packer for packing off a liner within the well.

Typically, in the drilling of a well, a borehole is drilled from the earth's surface to a selected depth and a string of casing is suspended and then cemented in place within the borehole. A drill bit is then passed through the initial cased borehole and is used to drill a smaller diameter borehole to an even greater depth. A smaller diameter casing is then suspended and cemented in place within the new borehole. Generally, this is repeated until a plurality of concentric casings are suspended and cemented within the well to a depth which causes the well to extend through one or more hydrocarbon producing formations.

Oftentimes, rather than suspending a concentric casing from the bottom of the borehole to the surface, a liner is suspended either adjacent the lower end of a previously suspended and cemented casing or from a previously suspended and cemented liner. The liner extends from the previously set casing or liner to the bottom of the new borehole. A liner is casing which is not run to the surface. A liner hanger is used to suspend the liner within the lower end of the previously set casing or liner. Typically, the liner hanger has the ability to receive a tie back tool for connecting the liner with a string of casing which extends from the liner hanger back to the surface. Liners may be used for both land and offshore wells.

A setting tool disposed on the lower end of a work string is releasably connected to the liner hanger which is attached to the top of the liner. The work string lowers the liner hanger and liner into the open borehole extending below the lower end of the previously set casing or liner. The borehole is filled with fluids such as drilling mud which flows around the liner and liner hanger as the liner is run into the borehole. The assembly is run into the well until the liner hanger is adjacent the lower end of the previously set casing or liner and the lower end of the liner is above the bottom of the open borehole. As can be appreciated, it is desirable to have the inside diameter of the liner be as large as possible to allow more space for additional liners to be disposed within the well.

When the liner reaches the desired location relative to the bottom of the open borehole and the previously set casing or liner, the setting tool is actuated to move slips on the liner hanger from a retracted position to an expanded position and into engagement with the previously set casing or liner. Thereafter, when weight is applied to the hanger slips, the slips are set to support the liner.

The liner hanger setting tool may be actuated either hydraulically or mechanically, see for example US-A-4712614. The setting tool can have a hydraulically operated setting mechanism for the hanger slips or can have a mechanically operated setting mechanism for the setting slips. A hydraulically operated setting mechanism typically employs a hydraulic cylinder which is actuated by pressure in the bore of the work string. In mechanically setting the liner hanger, it is usually necessary to obtain a relative downhole rotation of parts between the setting tool and liner hanger to release the hanger slips. The hanger slips are then one-way acting in that the hanger and liner can be raised or lifted upwardly but a downward motion of the liner sets the slips to support the hanger and liner within the well.

Then to release the hanger, the setting tool is lowered with respect to the liner hanger and rotated to release a running nut on the setting tool from the liner hanger. Cement is then pumped down the flowbore of the work string and liner and up the annulus formed by the liner and open borehole. Before the cement sets, the liner hanger setting tool and work string are removed from the borehole. In the event of a bad cement job, a liner packer and liner packer setting tool are then attached to the work string and lowered back into the borehole. The packer is set utilizing the liner packer setting tool.

Packers for liners are often called liner isolation packers. A typical liner top isolation packer system includes a packer element mounted on a mandrel. A seal nipple is disposed below the mandrel which stings into a tie back receptacle on top of or below the liner hanger. A liner isolation packer is used to seal the liner in the event of a bad cement job. Typically, the liner isolation packer is set down on top of the hanger and the packer is set by a setting tool to form a seal of the annulus between the liner and the previously set casing or liner.

Generally, the deeper a well is drilled, the higher the temperature and pressure which is encountered. Thus, it is desirable to have liners with liner packers which will ensure quality cementing of the liner so as to provide a high safety factor in preventing gas from the formation from migrating up the annulus between the liner and outer casing.

During the cementing operation, drilling mud or fluid in the annulus between the liner and outer casing is displaced by cement as the cement is pumped down the flowbore of the work string. First the drilling mud and then the cement flows around the lower end of the liner and up the annulus. If there is a restriction to flow in the annulus, the flow of the cement slows and a good cementing is not achieved. Any slowing of the cementing in the annulus allows time for the gas in the formation to migrate

up the annulus and through the cement to prevent a good cementing job.

Prior art liner top packers restrict the bypass in the annulus at the point of the liner packer. The diameter of the liner packer is just below the drift of the outer casing that the liner is being run through. The increased diameter allows for sufficient back-up for the liner packer to seal properly. However, this also restricts the bypass flow area around the packer causing higher fluid velocities and lower pressures that will either fluid cut the packing element or swab it off entirely. The reduced bypass area also tends to be a stopping location for any solids that may be washed up the well. These solids can packoff at the liner so as to set the liner packer prematurely.

In the cementing operation, the drilling mud is first pumped through the well at a high rate of speed to "clean the well" of any deleterious material. If there is a restriction at the liner packer, the fluid flow may cause the liner packer to set prematurely. If the liner packer sets prematurely, it seals the annulus to fluid flow and the cement can no longer be pumped down hole.

Conventionally, the liner packer has all of its setting mechanism disposed on a mandrel that is located on the outside diameter of the liner, i.e. is located in the annulus formed by the liner and outer casing. The by-pass area around the liner packer for the cement is formed by the annulus or annular space between the outer casing and liner. Thus, locating the setting mechanism for the liner packer on the outside of the mandrel limits and restricts the annular space for allowing the cement to by-pass the liner packer. Once the by-pass area is set, only a certain volume of drilling mud and cement is allowed to pass around the liner packer at any given time. If the flow rate of the drilling mud and cement is such that the drilling mud and cement cannot bypass the liner packer fast enough, the liner packer becomes a restriction to flow providing a back pressure on the drilling mud and cement.

As an example of the above, if a liner has a diameter of 11¾ inches (30cm) and the outer casing has a diameter of 13⅜ inches (34cm), the annular space around the liner packer provides approximately 12.2 square inches (78.7cm^2) of bypass. When the flow of cement encounters the liner packer, the bypass area is reduced to approximately one-half thereby causing the velocity of the fluid flow over the packoff elements of the packer to increase dramatically. This causes the fluid to cut the packing elements and may cause the packing elements to be eroded away. As the fluid flow over the packing elements increases, a low pressure area is created causing the packing elements to expand and get sucked up into the fluid flow. Further, as indicated above, this restriction to flow causes surge pressures downhole because the pumps at the surface are forcing fluids into a fluid filled annular column and the fluid flow is restricted at the liner packer causing the pressure to increase. If this pressure becomes great enough, the drilling fluids or cement may be forced into the formation causing formation damage.

Further, the packing elements of prior art liner packers have not been sufficiently rigid to allow the packing elements to stroke over a port in the packer mandrel since it is necessary for the prior art packing element to fit tightly around the mandrel to ensure sealing engagement. Thus, in prior art packers, any attempt to stroke the packing element over a port causes the edges of the port to tear or damage the interior sealing surface of the packing elements thus preventing them from attaining an adequate sealing engagement upon setting the liner packer.

The present invention overcomes the deficiencies of the prior art.

According to a first aspect of the present invention, there is provided a packer for sealing with an outer casing to prevent the flow of wellbore fluids, the packer comprising: a tubular body having a tubular wall with an aperture through the wall; a packing element movably

disposed on said tubular body between an open position allowing wellbore fluids to flow through said aperture and a closed position preventing wellbore fluids from flowing through said aperture.

According to a second aspect of the present invention, there is provided a packer for being disposed between an inner member and an outer casing to form an inner annular area and an outer annular area for the flow of wellbore fluids, the packer comprising: a tubular body having a tubular wall with an aperture through the wall; and, a packing element movably disposed on said tubular body between an open position allowing wellbore fluids to flow through said aperture and a closed position preventing wellbore fluids from flowing through said aperture; said tubular body and packing element being sized to allow the sum of the inner and outer annular areas to approximate the annular flow area of the wellbore fluids below said tubular body.

According to a third aspect of the present invention, there is provided a packer for packing off the annulus formed with an outer casing to the flow of wellbore fluids, the packer comprising: a tubular mandrel having a tubular wall with at least one aperture therethrough for the flow of the wellbore fluids; a stop member disposed on one side of said aperture; a packing element disposed in a first position on another side of said aperture; and, an actuator member for moving said packing element to a second position from said another side to said one side of said aperture position and causing said packing element to engage said stop member to compress said packing element into sealing engagement with an outer casing.

According to a fourth aspect of the present invention, there is provided a method of cementing a well, the method comprising the steps of: disposing a packer between an inner tubular member and an outer casing within the well; flowing wellbore fluids down the flowbore of the inner tubular member; flowing wellbore fluids up the annulus

formed by the inner tubular member and the outer casing; flowing wellbore fluids through an outer annular area formed between the packer and the outer casing; flowing wellbore fluids through an aperture in the packer; and, flowing wellbore fluids through an inner annular area formed between the inner tubular member and the packer.

The inner and outer annular areas may approximate the flow area of the annulus formed by the inner tubular member and the outer casing below the packer.

In a preferred embodiment, the liner packer assembly and method includes a liner packer having a tubular body with an aperture through the wall of the tubular body for the flow of wellbore fluids. A packing element is movably disposed on the tubular body between an open position on one side of the aperture for allowing wellbore fluids to flow through the aperture to a closed position on the other side of the aperture for closing flow through the aperture and for packing off the annulus between the packer and outer casing. An actuator member is mounted on the tubular body for moving the packing element from the open position to the closed position and against a stop member on the tubular body disposed below the aperture. As the actuator member compresses the packing element against the stop member, the packing element expands into sealing engagement with the outer casing. The actuator member includes a ratchet member which engages ratchet teeth on the outer surface of the tubular member so as to allow the packing element to move from the open position to the closed position but not from the closed position to the open position thus locking the packing element into the closed position and into sealing engagement with the outer casing. The distance between the aperture and the stop member is greater than the length of the packing element so that the packing element does not seal over the top of the aperture.

In operation of the preferred embodiment, the liner packer is disposed between an inner tubular string and an outer casing. The inner tubular string includes a work

string supporting a packer setting tool, packer, and a liner string. During the cementing operation, cement is pumped down on top of the drilling fluids in the well causing first the drilling fluids and then the cement to flow down the flow bore of the inner tubular string and then up the annulus formed between the inner tubular string and the outer casing. Upon first the drilling fluids and then cement reaching the packer, the fluids flow through the annular area between the packer and outer casing and also flow through the aperture in the wall of the tubular body of the packer and up the inside diameter or inner annular area between the packer and inner tubular string to avoid any restriction in flow past the liner packer. The inner and outer annular areas around the packer approximate the flow area below the packer between the inner tubular string and the outer casing.

One principal advantage of the liner packer of the present invention is that the liner packer allows an increase in the annular bypass area for the flow of cement during cementing operations. Thus, the liner packer of the present invention increases the bypass area allowing greater fluid flow and particularly avoiding a flow restriction.

The cross sections of the liner packer and the cross sections of the other metal members associated with the liner packer have also been reduced to increase the bypass area.

Other objects and advantages of the present invention will appear from the following description.

For a detailed description of a preferred embodiment of the invention, reference will now be made to the accompanying drawings wherein:

Figure 1 is a diagram of a cross-sectional elevation view of a well in which is suspended the liner assembly including a packer of the present invention;

Figures 2A-C are a cross-sectional elevation view of the liner hanger, liner packer and the setting tools for

the liner hanger and liner packer shown diagrammatically in Figure 1;

Figure 3 is a cross-sectional elevation view of the release nut and ratchet sleeve on the lower end of the packer setting tool;

Figure 4A is a partial cross-sectional elevation view of the liner packer and packer setting tool in the running position;

Figure 4B is a partial cross-sectional elevation view of the liner packer with the mandrel of the packer setting tool in engagement with the packer actuator assembly;

Figure 4C is a partial cross-sectional elevation view of the liner packer which has been set hydraulically;

Figure 4D is a partial cross-sectional elevation view of the liner packer and packer setting tool with the packer set mechanically;

Figure 4E is a partial cross-sectional elevation view of the packer setting tool in the release position;

Figure 4F is a partial cross-sectional elevation view of the packer and packer setting tool with the packer setting tool in the retrieving position; and,

Figure 5 is an enlarged cross-sectional elevation view of the liner packer shown in Figure 2B.

Referring initially to Figure 1, a liner assembly 10 is shown suspended within a well 12. The well 12 includes an outer casing 14 extending from the surface 16 down into the well 12 with its lower end cemented at 18. Outer casing 14 may be a previously set string of casing. After outer casing 14 has been cemented, the well is drilled deeper forming borehole 20. The liner assembly 10 is lowered through outer casing 14 and into borehole 20 by means of a work string 22. The top of the liner assembly 10 is suspended within the lower end of outer casing 14 so as to overlap outer casing 14. The lower end of liner assembly 10 is typically suspended off the bottom 24 of borehole 20.

The liner assembly 10 includes a liner hanger 30 and a packer 40 below which is suspended a pipe string forming the liner 26 for borehole 20. Mounted on the lower end of liner 26 is a landing collar 32, a float collar 34, and a shoe 36. Collar 34 and shoe 36 form a one-way valve which prevents the upward flow of fluids through liner 26. Disposed within liner 26, is a pocket slip setting tool 50 and a packer setting tool 60 below which extends one or more slick joints 42. Attached to the lower end 48 of slick joints 42 is a wiper member 44. The landing collar 32 provides a shear member 52 which receives a ball 35. Collar 32 also has a threaded receptacle to latch and lock wiper 44. The setting tools 50 and 60, liner 26 and work string 22 form a vertical flowbore 54 extending to the surface 16 for the passage of drilling fluids and cement. Likewise, liner 26 and work string 22 form an annulus 56 with borehole 20 and outer casing string 14 which extends to the surface 16. The annulus 56 extends from the surface 16 down to shoe 36 adjacent borehole bottom 24. Flowbore 54 and annulus 56 provide a flow path for drilling fluids and cement for the cementing operation to cement liner 26 within borehole 20, as hereinafter described in further detail.

<u>Liner Packer</u>

Referring now to Figures 2A-C and 5, liner packer 40 is disposed on liner assembly 10 (shown in Figure 1) below liner hanger 30. Liner packer 40 includes a barrel or tubular member 62 having threads 64 at its upper end for threaded engagement with the lower end of pocket slip liner hanger 30. An inner annular latch groove 66 is provided adjacent the upper end of tubular member 62 and is adapted for receiving a plurality of latches 160 on packer setting tool 60, hereinafter described in detail. The upper portion of tubular member 62 has a reduced outer diameter 63. A plurality of arcuate members 72 are provided around the circumference of tubular member 62 at the change in

diameter of member 62 to form a plurality of upwardly facing shoulders 68. Bypass slots 70 are provided between arcuate members 72 for the passage of well fluids and cement, as hereinafter described in further detail. Above and adjacent to shoulders 68 are a plurality of cement bypass ports 80 for the passage of well fluids and cement as hereinafter described in further detail. Above bypass ports 80 is disposed a pack off or packing element 90 and upper and lower compression rings 92, 94, respectively, which are positioned around a seal bore 74 on reduced diameter 63. One preferred packing element 90 is the ABC Packing Element manufactured by CDI Seals Incorporated. Above the upper compression ring 94 is a spacer ring 99 and a ratchet ring 96. Ratchet ring 96 has inwardly extending annular ratchet teeth 95 which are in engagement with ratchet teeth 76 around the outer circumference of tubular member 62 above bypass ports 80. Another spacer ring 98 is disposed between ratchet ring 96 and dogs 180. The teeth 95 of ratchet ring 96 and the ratchet teeth 76 on tubular member 62 allow ratchet ring 96 to move downwardly while preventing the upward movement of packing element 90. A plurality of longitudinally extending apertures 78 are azimuthally spaced around tubular member 62 for receiving retractable setting dogs 180 on packer setting tool 60, as hereinafter described in further detail. A retainer ring 98 is provided above ratchet ring 96 which is notched at 82 for dogs 180.

While running in and cementing, the drilling fluids and cement flow up that portion of annulus 56 below liner packer 40 which is formed between liner 26 and outer casing 14. The drilling fluids and cement are then allowed to flow through the outer annular area 56A formed by tubular member 62 and outer casing 14. Further, the bypass ports 80 below the packing element 90 allow wellbore fluids to pass through the body of the liner packer 40 and up through the inside diameter of liner packer 40 which forms an inner annular area 56B between packer setting tool 60 and liner

packer 40. Finally the wellbore fluids flow out the top of the packer setting tool 60.

The inner annular area 56B and outer annular area 56A approximate the flow area through that portion of annulus 56 between liner 26 and casing 14 below liner packer 40. During the setting process for the liner packer 40, the packing element 90 moves over the bypass ports 80 and bottoms out against the shoulders 68 of the packer tubular member 62. The packing element 90 is then set for sealing annulus 56 between liner 26 and outer casing 14.

The liner packer 40 allows for no or only a slight reduction in flow as the wellbore fluids come up the annulus 56 and bypass the liner packer 40. The bypass through the inside diameter of liner packer 40 significantly reduces the flow over the pack off elements 90 thereby reducing the effects of fluid cutting or possible swabbing. Further, the solids in the wellbore fluids will pass through the bypass ports 80 and settle inside the liner 26.

<u>Packer Setting Tool</u>

Referring now to Figures 2A, 2B, 2C and 3, packer setting tool 60 is shown disposed below pocket slip setting tool 50. Packer setting tool 60 includes a packer actuator and setting assembly 100 disposed around an inner mandrel 102 having threads 104 at its upper end for threaded engagement to the lower end of pocket slip setting tool 50. Packer setting tool mandrel 102 includes an outer annular dog release groove 106 disposed below packer setting assembly 100. A release nut 110 is mounted on mandrel 102 below release groove 106. Release nut 110 includes an inner threaded split ring 112 having outer threads which threadingly engage at 111 internal threads on release nut 110. Threaded split ring 112 includes an inwardly directed flange member 114 which is received within a notch 116 in mandrel 102 to prevent split ring 112 from rotating with respect to mandrel 102. The release nut 110 is also

disposed on mandrel 102 by means of a shear screw 118 which extends into a blind hole 120 in mandrel 102. As best shown in Figure 3, release nut 110 includes a plurality of longitudinally extending splines 122 disposed azimuthally around the outer circumference of release nut 110. The upper terminal end of splines 122 is bevelled at 124 and 126 for guiding release nut 110 into spline nut 172, as hereinafter described in further detail.

A lower mandrel 130 is threaded at 132 to the lower end of inner mandrel 102. A port 134 extends through the wall of the upper end of lower mandrel 130 just below threads 132. Ratchet threads 136 are provided around the circumferential lower surface of lower mandrel 130. The terminal end 138 of lower mandrel 130 is connected to slick joints 42. A ratchet sleeve 140 is mounted around the upper end of lower mandrel 130. Annular sealing members 135, such as O-rings, are housed in grooves in sleeve 140 for initially sealing off port 134. Sleeve 140 includes external upper ratchet threads 142 adapted for engagement with split ratchet ring 200 of packer setting assembly 100, as hereinafter described in further detail. A drag pin 149 is provided in the wall of sleeve 140 for engaging the external surface of lower mandrel 130. Sleeve 140 includes a lower inwardly facing annular groove 144 in which is mounted a lower split ratchet ring 146 having internal ratchet teeth 147 adapted for engagement with ratchet threads 136 disposed therebelow on mandrel 130.

Referring now to Figure 2B, packer setting apparatus 100 includes a body 150 and an actuator member or piston 152. Body 150 includes a latch retainer 154 threaded at 156 to its upper end. Retainer 154 and body 150 form an inner annular groove 158 for housing a packing seal 162 which sealingly engages the external surface of inner mandrel 102. Retainer 154 includes a plurality of apertures 164 housing retractable dogs or latches 160 which are received within latch groove 66 for supporting packer setting apparatus 100 on hanger setting tool 50. Latches

160 include a longitudinal bore 166 adapted for receiving threaded guide pins 168 for attaching latches 160 to retainer 154 while allowing latches 160 to move radially within aperture 166 on guide pin 168. An inner threaded counterbore 170 is provided in the lower end of body 150 for threadingly receiving a spline nut 172 having a plurality of internal splines 174 forming longitudinal slots therebetween. Internal splines 174 are spaced such that the longitudinal slots receive splines 122 on release nut 110, previously described.

Piston 152 includes an upper counterbore 176 adapted for receiving the reduced diameter lower end of body 150. A shear pin 178 extends between piston 152 and body 150. Piston 152 further includes an enlarged diameter portion 182 projecting radially outward. Enlarged diameter portion 182 includes a plurality of apertures or pockets 184 housing individual retractable setting dogs 180. Retractable setting dogs 180 each include a pair of arcuate flanges 185 which engage a retainer ring 186 extending around enlarged diameter portion 182 for maintaining retractable dogs 180 within pockets 184. Setting dogs 180 are spring biased radially outward by springs 188. Piston 152 further includes an enlarged inner diameter portion 191 which includes an inwardly projecting radial boss 192 housing a sealing member 194 which seals with lower mandrel 130 in its uppermost position best shown in Figure 4B as hereinafter described. Enlarged inner diameter portion 191, boss 192 and the lower terminal end of body 150 form an annular cylinder or chamber 190 upon lower mandrel 130 being raised to its upper position shown in Figure 4B. The lower terminal end 196 of piston 152 has a reduced outer diameter 197 for receiving a centralizer ring 201 which is maintained on reduced diameter portion 197 by a snap ring 198. Centralizer ring 201 contacts the inside diameter of tubular member 62 to centralize packer setting tool 60 within liner packer 40. Piston 152 is provided at its lower end with an inwardly facing annular channel 199 which

houses a ratchet ring 200 with inner ratchet teeth 202 adapted to engage ratchet teeth 142 on sleeve 140.

Liner Hanger

Referring now to Figure 2A, liner hanger 30 includes a tubular member 208 having a plurality of slips 210 mounted within slip slots 212 disposed around liner hanger 30. The upper end of slip slots 212 and the upper end of slips 210 have inclined camming surfaces at 214 for camming slips 210 radially outward and into engagement with outer casing 14. A threaded box 216 with left-hand internal threads is provided at the upper end of liner hanger 30 for receiving a running nut 220. Running nut 220 has outer left-hand threads which threadingly engage the inner left-hand threads of box 216. Nut 220 also includes a plurality of longitudinal apertures 219 for the passage of fluids. Running nut 220 includes a plurality of splined slots on its inside diameter for receiving splines 223 located on the lower end of kelly 228 at the upper end of pocket slip setting tool 50 as hereinafter described. Further details of the liner hanger 30 are disclosed in US-A-4712614 and in GB patent application no.__________ filed concurrently herewith, and entitled "Liner Assembly and Method", agent's ref. P6438GB, both incorporated herein by reference.

Pocket Slip Setting Tool

The pocket slip setting tool 50 includes an inner tubular mandrel 222 which includes a threaded pin at its upper end for threaded engagement to the threaded box on the lower end of kelly 228. Kelly 228 is threadingly connected to the lower end of pipe string 22 shown in Figure 1. A bearing housing 234 is received over kelly 228 and is attached thereto to form a junk cover for liner hanger 30. Housing 234 prevents deleterious material from falling into the upper end of liner hanger 30 and includes a plurality of ports 236 for the passage of fluids. The lower end of kelly 228 is in the form of a hex 232 having

splines 223 which form slots for receiving the internal splines on running release nut 220. The lower end of kelly 228 includes upwardly facing stop shoulders 221 for abutting engagement with the lower end of running nut 220.

A unitary hydraulic-mechanical actuator assembly 240 is disposed around inner mandrel 222 below kelly 228. Actuator assembly 240 includes an actuator sleeve piston 224 slidably mounted on the exterior of inner mandrel 222. A dog housing 227 is threaded to the lower end of piston 224 and includes a plurality of dogs 230 projecting through apertures 231. A shear member 229 is threaded onto the lower end of housing 227. The piston 224 has an inwardly facing annular flange 225 forming a hydraulic cylinder chamber 235 with an annular boss 237 which projects radially outward from inner mandrel 222. Seals are provided on flange 225 and boss 237 for sealing chamber 235. Ports 238 provide fluid access from the flowbore 54 of mandrel 222 to the chamber 235. A stop ring 239 is provided on mandrel 222 within chamber 235 to compress a spring 219 between flange 225 and stop ring 239. The shear member 229 includes shear screws 242 threaded into inner mandrel 222. An inwardly directed annular channel 243 is provided in the lower end of shear member 229 for receiving a split latch ring 245 having internal ratchet teeth 241. A dog release groove 244 is disposed around mandrel 222 such that upon split ratchet ring 245 engaging a lower ratchet ring 246, mounted around the lower end of inner mandrel 222, annular release groove 244 is positioned beneath dogs 230. Further details of the hanger setting tool 50 are disclosed in US-A-4712614, incorporated herein by reference.

Setting the Liner Hanger

Referring now to Figure 1, the liner assembly 10 is lowered into the bore 56 formed by outer casing 14 and borehole 20. As shown in Figure 1, the top of liner assembly 10 is a distance A above the bottom of outer

casing 14. The lower end of liner 26 is a distance B above the borehole bottom 24. Distance A, typically in the range of 200 to 500 feet (60 to 150m), is greater than distance B.

Referring now to Figures 1 and 2A-C, in the operation of the hanger setting tool 50, the hanger slips 210 can be set either mechanically or hydraulically. For hydraulic setting, the liner 26, liner hanger 30, setting tool 50, and pipe string 22 are lowered and located in the borehole 20 and casing 14 at a depth where the liner hanger 30 is to be set. The sealing ball or plug 35 is dropped through the pipe string 22 to ball catcher 52 which is releasably mounted in landing collar 32. At that time, the borehole of setting tools 50, 60, liner 26 and borehole 54 are sealed to prevent any further downward fluid movement. By pressuring up on the fluid in the pipe string 22, pressure in the annular chamber 235 first shears shear screws 242 and then the hydraulic force on the piston 224 (as well as the spring force), moves piston 224 upwardly on inner mandrel 222 causing the dogs 230 to move upwardly while engaging the lower end 211 of slips 210. The shear pin 215 for slips 210 is sheared and the slips 210 are moved outwardly along the inclined surfaces 214 causing slips 210 to engage well casing 14 for supporting the weight of liner 26. The pipe string 22 is then lowered and, upon right hand rotation of the pipe string 22, the running nut 220 unthreads from the box 216 due to their left-hand threads. At the same time, piston 224 unscrews from collar 227 so that inner mandrel 222 can be disengaged from liner hanger 30. Upon moving the pipe string 22 upwardly, the ratchet ring 246 on the lower end of inner mandrel 222 is received by and engages the split ratchet ring 245. Further, the release groove 244 is located beneath the dogs 230 so that the dogs 230 are moved inwardly and released from slips 210. The entire setting tool assembly 50, 60 is then lifted off liner hanger 30.

Alternatively, to set the liner hanger 30 mechanically, liner 26 is lowered in the well until it engages the bottom 24 of the well bore 20 to ensure that the piston 224 can be rotated relative to the liner hanger 30. By rotating the pipe string 22, shear pin 242 is sheared and spring 219 moves the piston 224 upwardly. The spring force of the spring 219 causes the dogs 230 to engage the lower end 211 of slips 210 and shears shear pins 215 and releases slips 210. Upon lifting the pipe string 22, the stop flange 221 below the running nut 220 contracts the nut 220. The pipe string 22 then is raised to move liner 26 to the desired location from well bottom 24 while slips 210 drag along the well bore surface and are being pushed outwardly by the spring force only. At the desired location for hanging liner 26, the pipe string 22 is lowered thus setting the slips 210 and hanging the liner 26 in outer casing 14. Next, the pipe string 22 is slacked-off so that load is removed from nut 220 to allow rotation of pipe string 22 to release the nut 220 and the hanger setting tool 50 from the liner hanger 30. At this time, inner mandrel 222 is raised so that the ratchet ring 246 is received by and engages split ratchet ring 245 and release groove 244 is aligned with and releases dogs 230 from slips 210.

<u>The Cementing Operation</u>

Referring again to Figures 1, 2A-C, and 5, to begin the cementing operation, the flowbore 54 is opened by pressuring down flowbore 54 (formed by pipe string 22 and setting tools 50, 60) to shear ball catch 52 from landing collar 32 and release the ball catch 52 with sealing plug 35. This allows fluid flow around the lower end of liner 26 and up the annulus 56 formed between liner 26 and borehole 20 and between pipe string 22 and outer casing 14. Cement is then pumped down flowbore 54 through the one-way valve in flow collar 34 and the one way valve in shoe 36 and around the lower end of liner 26. The cement then

flows up the annulus 56 adjacent borehole 20. As the cement approaches the liner hanger 30, a solid nose plug (not shown) with wipers is pumped down on top of the cement column and latches with wiper plug 44. The wipers on the plug wipe the cement from the inside diameter of pipe string 22. The wiper plug 44 is then run through the liner 26 wiping the cement off the inside diameter of liner 26. This provides for a smooth clean inside diameter.

As the cement flows up that portion of the annulus 56 between liner 26 and borehole 20, the cement reaches the liner packer 40. The liner packer 40 has not yet been set. The cement is allowed to not only pass through that portion of the annulus 56 between the liner packer 40 and outer casing 14 but also through cement by-pass ports 80, as shown by arrows in Figure 5, and up the annular area 81 between packer setting assembly 100 and tubular member 62. Annular area 81 also extends between the pocket slip setting tool 50 and liner hanger 30. When wiper plug 44 lands and latches into landing collar 32, the cementing operation is complete. Running nut 220, best shown in Figure 2A, includes ports 219 which also allow the cement, if necessary, to pass through junk cover 234 and out ports 236 and back into that portion of the annulus 56 between pipe string 22 and outer casing 14. Allowing the cement to flow through by-pass ports 80 and up annular area 81 inside liner packer 30 as well as up annulus 56 around liner packer 30 avoids any restriction to cement flow, as distinguished from the prior art.

Setting the Liner Packer

As soon as the cementing operation is completed, the liner packer 40 is set by the packer setting tool 60. Figures 2A-C and 4A illustrate the positioning of the packer setting tool 60 with respect to the liner packer 40 upon completing the cementing operation.

Referring now to Figure 4B, the lower mandrel 130 of packer setting tool 60 is raised by pipe string 22. As

sleeve 140 is received within the lower end of liner packer assembly 100, the upper terminal end of sleeve 140 engages downwardly facing shoulder 205 causing sleeve 140 to become stationary and move downwardly on lower mandrel 130 as the upward movement of sleeve 140 is halted by shoulder 205 and lower mandrel 130 continues its upward movement. In this lower position, lower ratchet ring 146 engages the external ratchet threads 136 on the exterior of lower mandrel 130. Simultaneously, sleeve 140 is received by upper ratchet ring 200 causing ratchet teeth 202 to engage ratchet threads 142 on sleeve 140. Also, the spline nut 172 on liner packer assembly 100 receives and abuts release nut 110 on mandrel 130. The bevelled noses 124, 126 (see Figure 3) on the splines 122 of release nut 110 guide splines 122 into the spline slots formed between the splines of spline nut 172.

Referring now to Figure 4C, the liner packer 40 may be set either mechanically or hydraulically or hydraulically and mechanically. To set the liner packer 40 hydraulically, the packer setting tool 60 is raised to its uppermost position as shown in Figure 4B. In this uppermost position, hydraulic chamber 190 is formed by the sealing engagement of sealing member 194 with lower mandrel 130. Previously, as shown in Figure 4A, chamber 190 is open. Further, hydraulic ports 134 register with hydraulic chamber 190. Upon applying hydraulic pressure down the flowbore 54 of pipe string 22, hydraulic pressure is applied to piston 152 causing piston 152 to move downwardly within the cylinder 190 with respect to mandrel 102 and liner packer 40. The retractable setting dogs 180 bear against the upper annular terminal end of retainer ring 98 shifting ratchet ring 96, spacer ring 99, and packer element 90 downward over the reduced diameter portion 63 of tubular member 62 until the lower terminal end of packing element 90 engages upwardly facing annular shoulder 68. The packing element 90 completely passes over by-pass ports 80. Packing element 90 is then compressed and radially

energized into sealing engagement with the inside diameter of outer casing 14. Further, the teeth 95 on ratchet ring 96 engage the teeth 76 around reduced diameter portion 63 so as to maintain packing element 90 in the energized position shown in Figure 4C.

Alternatively, the liner packer 40 may be set mechanically as shown in Figure 4D. Since the lower ratchet ring 146 has engaged ratchet threads 136 and the outer ratchet threads 142 on sleeve 140 have engaged ratchet threads 202 on ratchet ring 200, weight may be placed on the pipe string 22 causing the respective ratchet threads to transmit the load from the inner mandrel 102 to the packer setting assembly 100. Thus, the weight is transferred to retractable setting dogs 180 by means of piston 152 setting liner packer 40 in the sequence previously described.

Further, it should be appreciated that the liner packer 40 may be set hydraulically and mechanically. The liner packer 40 may be set hydraulically as previously described with respect to Figure 4C and then further set mechanically as described with respect to Figure 4D by placing weight on the pipe string 22 which is transferred to retractable setting dogs 180 to further compress and energize packing elements 90 on liner packer 40 into engagement with outer casing 14.

Referring now to Figure 4E, to release packer setting tool 60, pipe string 22 is rotated. During the rotation, the light shear screw 118 keeps shear release ring 112 rotating with mandrel 102 thereby causing it to rotate from underneath spline release nut 110. Thus, upon rotation, the spline release nut 110 is rotated off the threaded split ring 112. Upon pickup of inner mandrel 102, retractable setting dogs 180 are biased inwardly against springs 188. Upon raising inner mandrel 102, annular groove 106 is positioned beneath latches 160 allowing them to be cammed inwardly upon further upward movement of mandrel 102.

The packer setting tool 60 may then be retrieved from the hole as shown in Figure 4F.

The packer setting tool 60 further includes an emergency shear release. The inwardly directed flange member 114 on threaded split ring 112 located in groove 116 of mandrel 102 acts as a shear ring. Upward movement of mandrel 102 shears flange member 114 allowing annular groove 106 to be positioned beneath latches 160. The threaded split ring 112 in the lower end 102 of packer setting tool 60 is also a shear ring. The flange 114 on the threaded split ring 112 may be sheared allowing everything to be removed from the well.

In addition to the general statements of invention mentioned above, the present invention also provides in another aspect a packer for being disposed between an inner member and an outer casing to form an inner annular area and an outer annular area for the flow of wellbore fluids, the packer comprising: a tubular body having a tubular wall with an aperture through the wall; and, a packing element movably disposed on said tubular body between an open position allowing wellbore fluids to flow through said aperture and a closed position preventing wellbore fluids from flowing through said aperture; said tubular body and packing element being sized to allow the sum of the inner and outer annular areas to approximate the annular flow area of the wellbore fluids below said tubular body.

While a preferred embodiment of the invention has been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit of the invention.

CLAIMS

1. A packer for sealing with an outer casing to prevent the flow of wellbore fluids, the packer comprising:

a tubular body having a tubular wall with an aperture through the wall;

a packing element movably disposed on said tubular body between an open position allowing wellbore fluids to flow through said aperture and a closed position preventing wellbore fluids from flowing through said aperture.

2. A packer according to claim 1, wherein in said open position said packing element is on one side of said aperture and in said closed position said packing element is moved to the other side of said aperture on said tubular wall.

3. A packer according to claim 1 or claim 2, comprising a locking member mounted on said tubular body for maintaining said packing element in said closed position.

4. A packer according to claim 3, wherein said locking member engages said tubular body to maintain said packing element in said closed position.

5. A packer according to claim 4, wherein said locking member and said tubular body have interengaging ratchet teeth which allow said locking member to move said packing element from said open position to said closed position but not move from said closed position to said open position.

6. A packer according to any of claims 1 to 5, further including an actuator member mounted on said tubular member for moving said packing element to said closed position and compressing said packing element into sealing engagement with an outer casing.

7. A packer according to claim 6, comprising a locking member on said tubular body for maintaining said packing element in said sealing engagement.

8. A packer according to any of claims 1 to 7, further including a stop member on said tubular body disposed a distance below said aperture for engaging said packing element in said closed position.

9. A packer according to claim 8, comprising an actuator member mounted on said tubular member for compressing said packing element against said stop member and into sealing engagement with an outer casing.

10. A packer according to claim 8 or claim 9, wherein said distance is greater than the length of said packing element.

11. A packer according to any of claims 8 to 10, wherein said stop member includes fluted passageways for the passage of wellbore fluids.

12. A packer for being disposed between an inner member and an outer casing to form an inner annular area and an outer annular area for the flow of wellbore fluids, the packer comprising:

a tubular body having a tubular wall with an aperture through the wall; and,

a packing element movably disposed on said tubular body between an open position allowing wellbore fluids to flow through said aperture and a closed position preventing wellbore fluids from flowing through said aperture;

said tubular body and packing element being sized to allow the sum of the inner and outer annular areas to be substantially the same as the annular flow area of the wellbore fluids below said tubular body.

13. A packer for packing off the annulus formed with an outer casing to the flow of wellbore fluids, the packer comprising:

a tubular mandrel having a tubular wall with at least one aperture therethrough for the flow of the wellbore fluids;

a stop member disposed on one side of said aperture;

a packing element disposed in a first position on another side of said aperture; and,

an actuator member for moving said packing element to a second position from said another side to said one side of said aperture position and causing said packing element to engage said stop member to compress said packing element into sealing engagement with an outer casing.

14. A packer according to claim 13, wherein said packing element moves over said aperture in moving from said first position to said second position.

15. A packer according to claim 13 or claim 14, wherein said aperture opens the interior of said tubular member to the flow of the wellbore fluids.

16. A method of cementing a well, the method comprising the steps of:

disposing a packer between an inner tubular member and an outer casing within the well;

flowing wellbore fluids down the flowbore of the inner tubular member;

flowing wellbore fluids up the annulus formed by the inner tubular member and the outer casing;

flowing wellbore fluids through an outer annular area formed between the packer and the outer casing;

flowing wellbore fluids through an aperture in the packer; and,

flowing wellbore fluids through an inner annular area formed between the inner tubular member and the packer.

17. A method according to claim 16, wherein the inner and outer annular areas are substantially the same as the flow area of the annulus formed by the inner tubular member and the outer casing below the packer.

18. A method according to claim 16 or claim 17, wherein the flow of the wellbore fluids past the packer is substantially not restricted by the packer.

19. A method according to any of claims 16 to 18, further including the steps of compressing a packing element on the packer to close the aperture and sealingly engaging the outer casing with the packing element.

20. A liner assembly, including a packer according to any of claims 1 to 15.

21. A packer, substantially as described with reference to the accompanying drawings.

22. A liner assembly, substantially as described with reference to the accompanying drawings.

23. A method of cementing a well, substantially as described with reference to the accompanying drawings.

Patent Office

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Application No: GB 9704184.2
Claims searched: 1-15 and 20-22.

Examiner: E.L.Rendle
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Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): E1F (FKA, FKG, FJT, FJU)

Int Cl (Ed.6): E21B

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 1 077 562	(SPLAWN PAGE) see figures 1A and 2A.	-
A	US 4 334 582	(HALLIBURTON) see figure 3.	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		